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THE PRINCIPAL RESULTS OF RESEARCH WORK IN INSECT ECOLOGY

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Insect ecology as a field of entomological investigation dates back 30-35 years. Hence all the progress that has taken place in this field in the USSR has been during the post-Revolutionary period. The great incentive to a study of insect ecology is of course its practical importance. The rapid expansion of agriculture and the assessment of productivity in this country has focused considerable attention on those insect pests which destroy crop plants. This has provided a powerful impetus to the study of their ecology, for the different geographical and agricultural conditions under which cultivated plants are grown largely determine the extent to which crops are damaged by insect pests. Insects play an important role also as pests of cultivated timber. Furthermore, they are of considerable significance as vectors of human disease and diseases of domestic animals.

In this country, insect ecology underwent a rapid development in various directions resulting in the formulation of many, generally accepted, theoretical conclusions. During the last decade, however, there has been a noticeable decline in the intensity of research in this field. This is possibly due to the fact that the first phase of investigation into insect ecology, with its relatively rapidly obtained results, is over. Further research is likely to be more laborious, yielding results more slowly and requiring greater specialization; all of which naturally limits the circle of research workers and slows down the tempo of production of results. There are no doubt other causes for the decline in published work in this field and among them the last war takes first place.

Valuable results have been obtained in the following fields of entomological research: the position of insects in biocoenoses; habitat and zonal distribution of insects; numerical increases in insect populations; factors determining the range of insect species; insect migration; assessment of the effect of different environmental factors on the life of particular insect species; diapause and hibernation; insect systematics and ecology; the ecology of destructive species; toxicology in relation to insect ecology.

The study of biocoenoses has resulted in the accumulation of miscellaneous facts. It has been established that the role of insects in biocoenoses is that of consumers of plants or small predators. Their relationship to the biocoenoses is determined first and foremost by their nutritional requirements (Fridolin, 1936a and 1936b). This eliminates the possibility of the distribution of insects in biocoenoses being a casual or accidental affair. Food relationships in biocoenoses have been described as the outcome of historical and physiological changes (Kuznetsov, 1938). They may attain an extraordinary complexity and be highly specialized.

Changes in the specific composition of biocoenoses result from the historical process of evolution acting in conjunction with ecological adaptation. They may be accompanied by the increase or reduction in the territory of the biocoenosis as a whole. This question of the specific composition of insect faunas is closely linked with the temporal duration of particular biocoenoses.

The relative abundance of different insect species in a given coenoses undergoes regular but complex changes (Beklemishev, 1931). There is a characteristic seasonal variation in abundance, against the background of which slight daily fluctuations in numbers may be observed. The annual variation does not repeat itself exactly in successive years, but each year has its own characteristic pattern, similar to, but slightly different from that of other years. The influence of man exerts a profound effect on the numerical composition of biocoenoses, and his influence produces directional changes in their composition. Directional changes may also be observed in the

successive coenoses of newly colonized territories e.g., burnt ground, reclaimed swamp, river beds, etc. Such a cycle of change in the composition of biocoenoses may be accomplished in what is historically a short time, and the new coenosis may attain the completeness of others in its immediate vicinity.

The obvious practical value of information regarding the composition of biocoenoses lies in the possibility of directing their development so that they become "saturated" with insects of use to man. This is especially important in the case of biocoenoses of cultivated land, which always tend to be "unsaturated" as regards animal species, particularly insects. This is considered to be one of the reasons for the rapid multiplication of pests in such situations (Meier, 1939; Rubtsov, 1948), for under cultivation, conditions are present which restrict the reproduction of their normal parasites and predators. Unfortunately the extent of our knowledge relating to natural biocoenoses and those of cultivated land is quite insufficient for practical application, and this field of insect ecology must be regarded as one of the least thoroughly investigated.

Adaptation to habitat has been studied most thoroughly in locusts and allied forms. It has also been studied in such insect pests as the turnip moth, cabbage root maggot and beet weevils. A wide range of adaptability has been found to be the case among polyphagous insect pests which are also eurythermous. Many such species inhabiting different zones, undergo a change of habitat according to the zone in which they occur; thus in northern zones which are cold and wet, they inhabit the warmer and drier habitats, whereas in the drier zones of the south they seek out the cooler moister habitats. This confirms the presence of a stability in the relationship between insects and the physical conditions of their environment. Even in different geographical zones, individuals of a given species may display an adaptation to similar microclimatic conditions. Such changes of habitat are very characteristic of the Acriidae and Locustidae (Bei-Bienko, 1930; Predtechenskii, 1930 and of the meadow moth, turnip moth, and other widespread insect pests.

Many species of insect pests are known to be adapted to very definite environmental conditions, in the absence of which the pest is very rarely, or never, found. This is typical of oligophagous and monophagous species, e.g., cabbage root maggot and sugar beet weevil.

The close association between certain insects and particular localities is seen in the case of the "reservoir-sites" of many insect pests; such sites may prove to be centers from which mass migrations arise in favorable seasons. The recognition of this phenomenon has found practical application in controlling the Asiatic locust; for the periodic multiplication of this species on the plains sometimes heralds its mass invasion of cultivated areas. The destruction of this locust in those areas where the hoppers are beginning to swarm provides a reliable method of controlling this pest. The phenomenon of habitat-adaptation has received little general attention and in the case of many insect pests our knowledge of it is scanty and insufficient for the purpose of being used as a basis for suggesting control measures against them; although in the case of the cabbage root maggot and the beet weevil some measure of success has been achieved by the application of knowledge in this ecological field.

A study of habitat distribution among insects raises the question of the part played by environmental factors in their lives. The method of ecological profiles has enabled entomologists to investigate the importance of food relationships, humidity, temperature, light intensity, etc., in relation to habitat-adaptation for various species. At the present time, these problems are either still largely unresolved or it is too early to make definite assertions about their solution (Strel'nikov, 1935a and 1936).

The zonal distribution of insects is closely linked with the distribution of their major habitats. This has been studied mainly in the case of harmful species and particularly locusts (Filip'ev, 1928). For insects as a whole, only certain general features of zonal distribution have been noted (Arnol'di Bei-Bienko and others 1948, 1950-1953). Observations on the zonal distribution of insect pests have revealed a marked tendency for many southern species to invade northern agricultural centers of cultivation. In northern zones, individuals of an intrazonal type have already been formed from these southern species. This phenomenon is responsible for a considerable infiltration of southern species into northern agricultural territories, where they may give rise to important multiplicative foci and consequent widespread damage. In Europe, this has already happened in the case of the turnip moth as reported by Kozhanchikov, 1935, and in Siberia it has been found in the case of acridiid complexes by Rubtsov, 1932, while in the Far East it has happened in the case of the meadow owlet moth, as reported by Onisimova, 1953.

A relationship has been discovered between the zonal distribution of insects and their metamorphosis. Insects with incomplete metamorphosis are largely restricted to southern zones, where, numericaly, certain of their

species may be dominant e.g., locusts in steppes and semideserts. In the northern zones (e.g., forests and tundra) the dominant insects are those exhibiting a complete metamorphosis, whereas hemimetabolous forms are few and constitute a negligible percentage of the individuals there, according to Kozhanchikov 1938b. A similar relationship has been observed in the case of the vertical distribution of insect species in mountain zones.

The mass multiplication of insects and its causes has claimed a good deal of attention from ecologists. Special monographs have been devoted to the study of mass multiplication of the meadow owlet moth and of pentatomid bugs. Certain general conclusions have emerged in respect to the mass multiplication of insects as a whole. Considerable attention has been paid to the ideas propounded by Pospelov in 1911, regarding the effect of larval feeding and the amount of fat reserve in the body of the metamorphosing insect on its fecundity. This thesis which was first developed in connection with holometabolous insects (Lepidoptera) has since been expanded and applied to species exhibiting incomplete metamorphosis as, for example, phylloxera and pentatomid bugs (Larchenko, 1940). Finally attempts have been made to apply these generalizations to all insects (Larchenko, 1956). Such data has been used for the evaluation of the possible chances of a given population of insect pest undergoing mass multiplication in the following generation. Intensive and specialized study is required before we can definitely accept the possibility of generalizing about the effect of larval feeding and the role of the fat body in creating a reserve for imaginal life for different groups of insects with different types of development. It is necessary to separate the effect of external conditions throughout larval life on the insect as a whole, from their localized effect on the fat body, particularly as this latter tissue plays a different physiological role in various insect groups.

The death of larval stages has been shown to play an important part in the regulation of numerical increase and the prevention of mass multiplication among insect species. In addition to the part played by parasites in the destruction of insect larvae, climatic and other physical factors in the environment are important in this connection. When the natural, environmental factors undergo a shift toward the optimum for a particular developmental stage of a given insect species, then there is sharp reduction in the mortality rate and this leads to numerical increase and a tendency for the numbers of that species to assume "plague" proportions (Kozhanchikov, 1941). Experimental investigation of the effect of temperature and humidity on the development of such insect pests as the meadow owlet moth, stem borers, turnip moth etc., has enabled entomologists to establish hygrothermic optima for these species. However, we still have insufficient knowledge of the part played by physical factors and parasites in reducing the number of insects under field conditions. It is not yet clear whether it is the physical or the biotic factors which are responsible for determining the increase in number of an insect pest. This gap in our knowledge is due ultimately, to the difficulty of studying insect population dynamics in nature to the comparatively few investigations carried out on the role of parasites as agents controlling the mass multiplication of pests and to the small number so far dealt with.

The importance of a shift of physical factors, particularly hygrothermic conditions, in the direction favoring the multiplication of insect pests may be revealed by the use of the climograph under field conditions. In this way, warm, dry summers have been shown to favor the reproduction of the meadow owlet moth in the European forest zone(Vladimirskaya, 1934, 1935). In the case of the turnip moth in the middle belt of European USSR, it has been discovered that favorable environmental conditions influence the duration of larval life, such that under these conditions the moth produces one and a half generations per annum instead of a single one, with a consequent increase in numbers (Filip'ev, 1929). The importance of this phenomenon is also to be seen in relation to the necessity for harmful species of pentatomid bugs to complete their growth before the harvesting of the grain. The coordinating mechanism here is worthy of a special study.

Conditions during hibernation as possible agents in the reduction of insect pest populations have been discussed by many authors and all are agreed that they play an important part. In order to understand why certain insects undergo mass multiplication it is necessary to have some idea of the potential fecundity of insect species. Differences in potential fecundity may condition the tendency toward mass multiplication of certain species, according to Kozhanchikov, 1948a. Certain species are characterized by a very high potential fecundity, although their reproductive capacity is not usually greatly different from neighboring forms. For example, the maximum reproductive capacity of the turnip moth is 2000 eggs, that of the cotton owlet is 3000 eggs and that of the gypsy moth 2800 eggs per female. However, the normal reproductive capacity of all these forms is less than one fifth of the figure quoted for the maximum. Nevertheless, all three species possess a high resistance to unfavorable environmental conditions. In most of the developmental stages they are eurythermous,

euryhygric, partly euryphagous and not infrequently resistant to starvation. They possess some developmental stages which are susceptible to the influence of environmental conditions, but these stages do not occupy so much of the life cycle as those of most insects. It has been established that the ontogenetic development of most insects liable to become exceptionally numerous is characterized by its eurybiontic nature and by its resistance to the effect of the environment and thus it differs from the development of those species that never assume "plague" proportions. The latter species often become markedly adapted to particular environmental conditions and lose their capacity to resist conditions which are unfavorable, according to Kozhanchikov, 1952.

The exact part played by diseases and parasites in the critical phases of mass multiplication of insect pests is still incompletely understood; however the virulence of insect diseases may be thought of in terms of a relationship between the insect organism and the environment.

The very great complexity of the phenomenon of mass multiplication in insects is now generally recognized and consequently one-sided hypotheses attempting to explain the phenomenon have been largely discarded. For example the idea that mass multiplication of insect pests results from the breakdown of the normal balance between them and their parasites is now regarded as inadequate. The role of parasites in checking the waves of multiplication has been shown to be significantly less than was first imagined. A subsequent theory concerning the part played by climate in controlling outbreaks of insect pests also has had to be greatly modified, for climate exerts a specific effect both on the pest tending to increase in numbers and on parasites and predators tending to check its increase. The synergistic effect of factors affecting the multiplication of insects is now generally recognized. This synergistic effect may apply both to survival and reproduction of individuals (Kozhanchikov, 1940). Where maximum fecundity has been attained, synergism may change the abundance of a species in the course of a single generation, depending on the particular ecological conditions prevailing at the time. The latter constitute an important prerequisite for the attainment of optimum multiplication. The theoretical foundation upon which a solution to the problem of mass multiplication might be built has not yet been worked out, although numerous hypotheses have been propounded (Kozhanchikov, 1953b).

Ecological investigations have thrown some light on the problems of geographical distribution of insect species. A high degree of correlation has been established between the distribution of insects and the degree of stability of their particular environments. Martynov, 1929, has demonstrated a relationship between widely distributed aquatic insects and their habitats in still or slow-moving waters. Conversely, insect species of swift-flowing mountain streams, rivers and springs, living in diverse, unstable and changeable environments, are frequently restricted in their distribution. It has been shown that the distributional limits of terrestrial insect species, and indeed of the whole fauna, correspond with the limits of stable and changeable climatic conditions, particularly with respect to the magnitude of diurnal and annual amplitudes of temperature variation (Kozhanchikov, 1946b). Moreover, it has been established that relict species of insects tend to be confined to habitats of great stability as regards environmental conditions e.g., coniferous, mountain forest (Kurentsov, 1936).

Ecological investigations into the distribution of insect habitats, together with a study of mass multiplication of insect has revealed a way of defining the range of a particular species. It is now clear that a species shows a discontinuous type of ecological distribution at the edge of its range, and even throughout the range as a whole its distribution, as regards numbers of individuals, is far from uniform. This fact has great practical importance in relation to the density of insect populations over great areas, for it demonstrates the unsuitability of using mean densities as a guide to actual distribution and stresses the importance of a knowledge of the actual density at a given point and the reasons for lack of uniformity in distribution. Within the limits of the total range of any insect species there exist habitats in which individuals can survive but not multiply. Such habitats are those of low population density and this is one of the reasons for lack of uniformity in population density over a wide area. Under the most favorable ecological conditions, which occur toward the center of the distributional range for a given species, and where optimum "habits" are widely distributed, the actual number of individuals is highest. It is in this central area of distribution that the population of an insect pest is most likely to assume plague proportions. This has been shown to be true in the case of the turnip moth, the cabbage white butterfly, the meadow owlet moth, the stem borer moth, the gypsy moth, the Asiatic locust and several other species (Kozhanchikov, 1935b, 1936c, 1937, 1938a, 1939b, 1941, 1950c, 1953b). In regions intermediate in position between the central zone and the peripheral zone of the total range, environmental conditions are not stable, and habits which were completely suitable for the species in question are few and far between. In this zone it is only occasionally and "accidentally" that a pest assumes plague proportions, although the same species may frequently do so in the central zone.

From what has been said it is obvious that the boundaries of distribution among insect species are determined by highly complex but ecologically specific laws. One of the simplest of such boundaries is the northern limit of distribution for insects of temperate latitudes, for this limit is determined either by insufficient warmth which prevents the completion of the life cycle or by the failure of the species to adapt itself completely to overwintering (Kozhanchikov, 1936c, 1937; Danilevskii, 1939, 1949). At first adaptation to overwintering was treated only in relation to cold resistance. Later, however, it was recognized that the ability to resist cold was only one of the factors involved in the successful hibernation of a species and not always the most important. It is now realized that resistance to low temperatures is merely a function of the physiological make-up of the insect organism. This make-up changes well in advance of hibernation, often several months before any effect of cold is experienced, and in the majority of insects the change in physiological make-up is a cyclical phenomenon to which the name diapause has been given. Diapause is either obligatory for all members of a species, i.e., it is observed in every generation, or it is produced as a result of certain environmental conditions dependent on a particular ecological situation. The restricted distribution of certain species in southern temperature latitudes may be explained in terms of this phenomenon, for the most characteristic of such species have an obligate diapause. The distribution of such cryophillic forms in southern latitudes may be restricted, therefore, by the direct influence of high temperatures (Kozhanchikov, 1947b). The continental limits of palearctic species e.g., the eastern limits of European forms and the western limits for eastern Asiatic forms, are determined in most cases by the peculiarities of the weather during the autumn and spring periods, according to Kozhanchikov, 1950b.

Diet plays an important part in determining the distribution of insects, particularly in the case of those phytophagous species which are mono- and oligophagous (Kuznetsov, 1930). These latter species show a high degree of adaptation toward their food plants which are always more widely distributed than the insects themselves (Kozhanchikov, 1937, 1947b, 1950c). Polyphagous species of insects have one great advantage—the possibility of feeding on different plants in different parts of their range. Thus, it is true to say that diet may be the most important condition in determining the habitat distribution of insects but it is not a factor which limits their geographical distribution.

Insect migration, whether it be diurnal or seasonal, possesses great theoretical interest, in relation to the distribution of species, and equally great practical importance in the devising of control measures against insect pests. So far comparatively little study has been made of the ecology of migration, except in the case of the following: the daily migration of insects in general (Beklemishev, 1931) and of locusts (Plotnikov, 1927; Predtechenskii, 1934); the seasonal migration of aphids, pentatomid bugs, many Cicadas, beetles, ladybirds and certain other species. Experiments have been carried out with a view to determining the routes taken in the seasonal migration of the desert locust, as reported by Predtechenskii, 1934; but these gave inconsistent results, according to Shcherbinovskii, 1952. Seasonal migration of certain insect pests e.g., the meadow owlet moth, is as yet only suspected but not confirmed. Actual experiments conducted with this species have given no definite results according to Stel'nikov, 1935b.

Thermal conditions have been shown to exert a definite influence on the larval stages of locusts. The movement of hoppers from the ground onto plants and back again, which was thought to be a trophic reaction, has been found to be influenced by temperature. Horizontal migration results from an increase in temperature, which stimulates larval activity. It may be prolonged throughout the warm part of the day, or under the influence of too high a temperature in the hottest hours it may cease for a while. The migration of adult locusts depends on more complex stimuli (trophic and thermal); it is conditioned also by physiological factors emanating from the maturing gonads (Pospelov, 1926). The late seasonal migration of harmful pentatomid bugs coincides with a change in their physiological condition as they pass from active state to diapause. The more complex seasonal migration of aphids, in which beside external conditions (trophic and climatic) and the physiological state of the individual, hereditary influences play their part, manifests itself as a cyclic phenomenon over successive generations. As yet, the analysis of all the diverse conditions affecting insect migration is far from complete, despire the fact that, because of the great practical importance of the topic, the literature in this field is already voluminous.

Experimental analysis of the reactions of insects to external influences reveals that they select those conditions in the environment which are optimum for their survival. Insect behavior tends to "counteract" environmental change and maintain the individual in conditions as near the optimum as possible. It has been shown

that the temperature preferred by an insect, which is confronted with a wide range of choice in this matter, is that which approaches most nearly to the optimum for the species (Zenyakin, 1937). Lack of complete correspondance between the specific optimum for a given species and the temperature selected by individual members may always be explained with reference to two factors: the varying degrees of activity shown by different individuals, some of which fail to reach optimum conditions and remain in the merely tolerable, and the actual change of physiological state in the individual as a result of preceding environmental conditions. The latter factor for a brief time may cause the individual to require temperature conditions somewhat different from the optimum for the species. These two factors are responsible also for the observed differences in threshold sensitivity toward temperature shown by different individuals of the same species. A similar principle has been established in relation to food preferences.

As yet, the analysis of preferences displayed by insects for particular environmental conditions is incomplete. Two types of reaction have so far been distinguished, and both are conditioned by the sensitivity of the insect to environmental conditions and by the degree of development of its sense organs. The less active species of insect can rarely avoid unfavorable conditions, so that after being confronted with a choice they may be observed both in "tolerable" and optimum conditions. In this case the zone of selected conditions is a wide one. Those insect species which are extremely active and, also, highly sensitive to environmental changes, because of their acute sense organs, speedily seek out optimum or near optimum conditions and therefore their zone of preference is well defined and limited.

Apart from the descriptions of ways in which insects react to particular environmental conditions very little has been done in the way of analyzing their reactions. Taxes and reflex actions are known to play an important part in insect behavior but so far these phenomenon have not been investigated from the standpoint of methods of control for insect pests, except in the case of the hydrotactic response of locusts, and the phototactic response of many species; this latter response is widely used in the trapping of insects. The role of instincts in insect behavior and in migration has received appraisal in general terms. It is obvious that insect behavior still requires much careful ecological investigation.

The principle of specific optimo for every environmental condition among insects, is an important theoretical concept. When every external factor is at its optimum then, in a given species, there is much less expenditure of energy in the process of growth and development and consequently a reduced consumption of food reserves than in the case of any other physiological state (Kozhanchikov, 1934, 1936 a). This has been found to be true for temperature, humidity and diet. Under optimum conditions, the organism requires a lower calorific intake and therefore less food is needed than under conditions in which it has to regulate its own physiological processes in relation to the environment. The tempo of living and of growth under optimum conditions is high but not maximal. Retardation of development and suppression of growth by too low temperatures or conversely, very rapid development at too high temperatures is always detrimental.

Under optimum conditions of growth and development the larval death rate is at a minimum and the fecundity and longevity of the adults is very high.

The optimum conditions of existence for a given species always correspond to the conditions under which the species evolved in the first place. Thus the optimum temperature regimes of various insects are those which prevailed in their original habitats. The optimum dietary conditions are those to which the species was adapted historically. Temperature, humidity and dietary optima, being specific for different insects exhibit great stability, for they correspond to the particular type of metabolism characteristic of the species in question. Under optimum conditions there is the fullest coordination between the physiological processes of the organism and the external environment.

Optimum temperature, dietary and other environmental factors can be specified for particular phases of development i.e., they must be considered as dynamic entities of a cyclical character which alter as ontogenesis proceeds. These optima, changing with different phases of the life cycle, always bear a relationship to the annual sequence of events in nature, a sequence to which each phase of development in a given species is adapted (Kozhanchikov, 1950a, 1950b). There are sharp differences between optimum conditions for active and quiescent phases in the life cycle, especially where a diapause occurs. In general, the vital optimum for each species is an indication of prolonged adaptation in the development of all its phases to the conditions prevailing in the habitat.

This analysis of environmental factors and their influence on insect life has received intensive study and much has been learned in this field. In relation to temperature, there has been established the existence of thermal threshhold values, effective temperatures and effective temperature ranges. The thermal threshhold value is only constant for individuals of uniform physiological make-up in the same phase of development. It is rarely constant for the whole of the life cycle, but more often than not shows a sharp difference between different phases of development and may even vary between one instar and another. Sometimes the thermal threshhold value before hibernation is different from that after hibernation in the same phase of the life cycle, as is the case for eggs of the winter measuring worm moth, the pupa of the grain owlet moth and certain other species.

The aggregate effective temperature is usually fairly constant in a given species, but as it is related to the duration of the life cycle in individual members, it is always greater when thermal, feeding and humidity factors are subnormal i.e., when individuals have to adjust themselves to adverse environmental conditions. The aggregate effective temperature for certain species of insects is very high, and in this category fall those megathermic forms of southern latitudes which exist on diets which are difficult to assimilate e.g., xylophages. Insect pests are for the most part members of that category in which the aggregate effective temperature is low. Such forms are characterized by a considerable lability in their developmental processes i.e., they speedily adapt themselves to new and different temperature conditions in the environment (Kozhanchikov, 1946a, 1949). The range of temperature over which development is possible is different for different species and is roughly proportional to their capacity to regulate their own temperature under different environmental temperatures. This regulating reaction is characteristically expressed by changes in the respiratory processes of the insect under different temperature conditions. In eurythermous insects, the short-term effect of unfavorable temperatures may be observed in the regulatory variation which takes place in their gaseous-exchange (Kozhanchikov, 1956b).

The aggregate effective temperature and the thermal threshold value for the various developmental phases serve as a measure of the extent to which a given species is thermophilic and provide a useful guide for assessing the probability or otherwise of its survival in northern latitudes and of its adapting itself to feeding on plants there. From a knowledge of these statistics, it is possible to work out short-term prognoses of the time of appearance of particular stages in the development of insect pests under natural conditions. Information regarding temperature threshold values is used theoretically in relation to studies on cell division. The cessation of cell division brings about a cessation of all growth and development. The temperature range over which this occurs is usually sharply defined for a given species and highly characteristic of it, for cellular activity is the product of metabolic processes some of which are unique for the form in question. The maximum temperature threshold value is not the same as the upper limit of temperature for an insect. The latter corresponds to the thermal death point and this is always higher than the maximum threshold value for development of a species. The difference between these two statistics varies in different species of insects.

The significance of thermal changes in development and whether they are an expression of physiological or ecological factors, is a long standing controversy among entomologists. It has been made clear that any increase in the daily temperature range has a deleterious effect on all insect species which have been investigated. Such an effect is linked in every case with nutrition, as an increase in the daily temperature range influences food consumption. Kozhanchikov, 1952, found that temperature change had no adverse effect on the development of caterpillars until it was sufficiently marked to curtail their feeding and thus reduce their food consumption. The effect on nutrition cannot, however, be the only effect of an increased temperature range for the latter can have deleterious effects on such developmental phases as eggs and pupae which do not feed. There is a relationship between the extent to which developmental processes in a particular species are labile and its resistance to thermal change; for the greater the lability of developmental processes the more readily can a species adapt itself to an increased amplitude of temperature. Insects of stable natural habitats experience deleterious effects as a result of slight change in temperature e.g., Dipthera coenobita Esp. (Lepidoptera). Conversely, insects of habitats displaying a changeable temperature regime, show a considerable degree of resistance to an increased amplitude of daily temperature.

The effect of light and solar radiation plays a great part in determining the habit distribution of insects in nature. The thermal effect of solar radiation has already been established. It is practically the same as the effect temperature has on development, although it is necessary to stress that the absorption of heat rays by insects is highly specific. Hence, in considering thermal effect of solar radiation, each species of insect must be considered separately.

The duration of day and night i.e., the effect of photoperiodism, has a complex and specific influence on the formation of migratory aphid individuals (migrantes, sexuparae) and determines the presence or absence of a facultative diapause. The importance of light conditions is especially great in the case of insects of boreal zones where photoperiodism is most marked, and in the polar zone where the thermal effect of solar radiation during the day in summer is enormous. So far, little work has been done on the effect of light on the growth of insects, on their fecundity, on the longevity of the imago, on their survival or their failure to survive.

The effect of diet, as of thermal factors is complex and diverse. When the diet is suboptimal, for example when an insect is not feeding on its normal food plant but on a closely related species, growth is depressed and the more abnormal the diet the greater the depression. The growth rate falls and death overtakes those individuals which feed on a diet which is grossly abnormal. Deviations from the dietary norm always affect individuals, by depressing the growth rate, and lowering fecundity and longevity of the imagos. Thus it has been established that the effect of diet on the life of insects is similar to that of temperature (Danilevskii, 1935; Kozhanchikov, 1937, 1939a, 1950a).

Such secondary components of insect food as glucosides, alkaloids and essential oils etc.,appear to have no direct effect on the nutrition of insects, as was at one time supposed (Kutnetsov, 1930); proteins are the most important substances in determining the suitability or otherwise of a particular diet. It has been found that the secondary components of a particular diet are unable to render it more suitable for a given species of insects if the protein content of the diet is inadequate (Kozhanchikov, 1939a, 1951). Thus glucosides, alkaloids, essential oils and other such components of the diet are only of secondary importance in insect ecology, though they may play some part as olfactory and gustatory stimulating substances.

The moisture content and the chemical composition of the medium in which insects live affect their growth rate and metabolic activities, although moisture content has not such a profound effect on the growth rate as have dietary and thermal factors (Kozhanchikov, 1937, 1950c). The slight influence that environmental moisture has on insect growth is in sharp contrast to its profound influence on the survival and fertility of individual insects.

The effect of soil conditions on insects has been studied mainly in relation to the distribution of habitats among pests. The nature of the soil has been shown to have considerable importance in the case of vine phylloxera infestation. In certain types of soil this pest does not attack grapevines. This has been found to be the case in such soils as the dusty, fine-grained marls of Transcaucasia (gazha), on which grapevines are widely cultivated (Prints, 1935). Soil conditions have been shown to have considerable importance also in determining the type of vegetational cover, which in turn decides whether a particular habitat will be preferred by a given insect species. This has been demonstrated in the case of harmful owlet moths by Shchegolev, 1925; for insects inhabiting river valleys by Krishtal, 1936; for cockchafers by Berezina, 1937; and for elaterid beetles and many other insect species. So far however, the whole complex of soil factors has not been investigated from the standpoint of their effect on insect existence, although certain elements of the complex, such as temperature and humidity will not differ in their effect from that shown when they are outside the soil complex. The role of the soil as an environment in the evolution of insects has received special study from Gilyarov, 1948.

Great stress has been laid by ecologists on the study of the diapause in insects. Zorin first demonstrated,in 1925,the existence of a facultative diapause in the cabbage snout moth and pointed out that the diapause, although potentially characteristic of all members of the species, only manifests itself under certain well-defined environmental conditions. When caterpillars of this species develop at reduced temperatures they always undergo a diapause preparatory to hibernation; whereas when they develop at higher temperatures there is no diapause and pupation occurs in the same year as hatching from the egg. It was later shown that facultative diapause is only a special case of the general phenomenon of insectan diapause, which is normally characteristic of all individuals belonging to the given species and occurs under a wide variety of environmental conditions (Kozhanchikov, 1940). It is now known that in addition to temperature, a change of diet (especially that involving a change in chemical constitution) can bring about facultative diapause (Shteinberg and Kamenskii, 1936; Zolotarev, 1940), as can a change in the length of day, photoperiodism (Danilevskii, 1956). It is usually shortening daylight which stimulates the onset of facultative diapause. It may also be shown that among dietary factors, the feeding on older plants and on leaves which are covered with soot influence the onset of diapause, although less distinctly than do other factors. The environmental temperature is the principal factor in determining the onset or otherwise of insectan diapause and it creates a background against which the other influences exert a less well marked effect. The paramount importance of the temperature regime in controlling diapause is evident from the fact that in

species which normally exhibit facultative diapause, successive broods of insects only occur in those years which are warmer than usual and the warmer the year and the longer the growing season the more broods can be observed. A relationship has been demonstrated between facultative diapause and temperature by Kozhanchikov, 1948b and 1950b, between diapause and light intensity by Danilevskii, 1953 and 1956, and between diapause and specific dietary factors. Danilevskii, 1956, stated that in certain species, there may be differences in reaction between local subspecific populations as regards the conditioning of diapause onset by a single factor.

Obligatory diapause is also a heterogeneous phenomenon: it not only makes its appearance at different times of the life cycle in different species, but it does so under diverse optimum conditions and it lasts for varied lengths of time. At low temperatures, diapause may persist for several months in pupae of swallow tail and cabbage white butterflies and in the egg stage of the gypsy moth and of several other species, whereas in the egg stage of the Asiatic locusts diapause only lasts for a week or so under similar conditions (Kozhanchikov, 1948b, 1954). The duration of the diapause may differ between individuals of the same species, but in this case we have no definite knowledge as to what factor is determining the difference. It is quite clear that the phenomenon of diapause in insects has arisen as an adaptation to living in climates showing a marked seasonal variation of temperature with cold winter months. Initially diapause must have arisen in the larval and imaginal phases and only at a later stage of insect evolution did it become a feature of the quiescent phase i.e., the egg and pupal stages, according to Kozhanchikov, 1956c.

The adaptation of insects to hibernation has only been studied in the sense of their resistance to cold up to the present time (Sakharov, 1930; Ostapets, 1926). A detailed study has been made of those factors such as the total water content of the body (including both the water combined with the protoplasmic colloids and free water), the amount of fat present and the sugar content of the body fluids. The possibility of anabiosis in insects has been admitted and has been studied in relation to their ability to withstand supercooling, as reported by Lozina-Lozinskii, 1935, 1937. Later, it became apparent that cold resistance is only a single factor in the general adaptation of insects to hibernation. The interruption of normal development is a more important factor in hibernation of insects than is resistance to low temperatures, for these can be evaded by moving down into the soil. Several insects are known to be resistant to cold in their various life cycle phases but to have no diapause, for example certain cutworms (Laphrygma); these undergo mass movements during the hibernation period but cannot live in regions with prolonged hard winters (Kozhanchikov, 1939c). Adaptation to overwintering is characterized by specific metabolic changes, which are coincident with a sharp drop in cellular activity and a cessation of cell division; these changes involve a transfer to anaerobic respiration and result in a resistance to the effects of low temperature, according to Kozhanchikov, 1929c. Diapause represents the most complete adaptation of insects to winter conditions and results in a cessation of developmental processes, so that the organism is protected against harmful environmental effects for several months; during this period the organism is sustained by anaerobic forms of metabolism. The insect cannot be said to undergo anabiosis at low temperatures for its respiration (viz., a metabolic activity) is maintained the whole time, providing it continues to survive in the given conditions (Khalabukhov, 1934; Kozhanchikov, 1935a, 1939c).

The question of insect variability was first dealt with from an ecological standpoint on the basis of statistical variation i.e., probability. Statistical analysis was used in relation to such variants as the gregarious and solitary forms of Asiatic locusts (Alpatov, 1927). A study of the effect of environmental factors on the variability of insects has placed many observable features on a firm basis. For example, those variations in the structure of the Asiatic locust, which are characteristic of the gregarious phase or the solitary phase, have been shown to depend not on chance but on definite interaction between the locust nymphs when they are most closely congregated and also on genetic factors (Plotnikov, 1924, 1927). However, a great many of the more complex problems of variation, particularly those of an ecological nature, remain either unresolved or of highly questionable solution.

Variation of the extent to which various organs are developed, together with variation in their form and proportions have been studied in correlation with the variability of certain biological properties of the insect e.g., fecundity and length of life (Kozhanchikov, 1947c). It has been established that all these characteristics display a different degree of variability among the individuals of a particular species depending on the conditions prevailing at the time of development. If development takes place under optimum conditions, then fecundity, longevity and body size show very considerable variability whereas the form of particular organs and the proportions of the body show very little. Under less favorable environmental conditions the converse is true; longevity and fecundity, although both reduced show little variability from one individual to another whereas the form and proportions of organs vary markedly, according to Kozhanchikov, 1940.

On comparing geographical races of insects with forms which arise regularly under experimental conditions, it is apparent that certain of the former are the result of particular environmental conditions. This is so in the case of the turnip moths which occur in western Siberia and Central Asia, viz., Agrotis segetum Schill. forms glaucina Kozh. and pallida Stgr. The first of these arises from larvae which develop under the influence of low temperature and rather high humidity, the second under the influence of heat and low humidity. Similarly it is possible to regard the light colored form of Acronicta lutea Brem. et Grey - form coptera Btl. - as arising under conditions of lack of warmth in the larval stage. In nature, such conditions occur near to the northern limit of its range (Kozhanchikov, 1940, 1950c). In addition to the geographical forms of insects which can be explained in the light of ecological investigations, there are others which must have arisen as a result of more complex influences than those produced by the effect of environmental factors on ontogenesis.

Ecological investigations into the variability of insects under the influence of particular environmental factors have a distinct bearing on the problems of systematics. Although such investigations appear to be far removed from the field of taxonomy, they affect certain questions of intraspecific differentiation in insects. The most obvious ecological influence at work here is in the differentiation of subspecific, trophic forms, which are well exemplified in our native fauna. These are usually local varieties, such as the variety of Lochmaea capraea L. which occurs in the northwestern part of the range of this species and is associated with birch; this form has occurred once in ecological experiments, according to Kozhanchikov, 1946b. It can be shown, that in nature new trophic varieties of insects require very long periods of time for their formation, unless they arise as mere modifications in response to particular environmental influences. In the latter category fall such examples as the two forms of human louse, Pediculus humanus L., of the Asiatic locust Locusta migratoria and others. Attempts at introducing special taxonomic categories for such cases have not been justified by the facts and have now been abandoned. It should be clearly understood that modifications in the behavior of individuals, which arise in the course of a single generation subjected to a distinct feeding regime are only physiological reactions of poly- and oligophagous species, and do not represent the initial stages in the divergence of intraspecific varieties (Kozhanchikov, 1956b). Apart from these, there are many examples in nature of ecologically determined intraspecific forms and closely related species. (Kozhanchikov, 1946b, 1950c, 1956b; Kurentsov, 1950). These would seem to have undoubtedly arisen in relation to the effect of environmental conditions but exactly how they have arisen is still not completely understood.

A study of the ecological characteristics of insect pests has revealed their specificity and their undoubted adaptation to living on cultivated plants, in food stores and in human dwellings (Gilyarov, 1945; Kozhanchikov, 1948). It is difficult for insects with protracted life cycles to adapt themselves to field conditions where annual grain crops are grown, particularly where the insect spends a considerable part of its life cycle associated with the soil. On the other hand it is relatively easy for species which are associated with plants only during their vegetational phase to become pests under conditions of cultivation; this is exemplified by such familiar forms as pentatomid bugs, turnip and stem-borer moths and cotton and meadow owlet moths. Even more specific adaptations are shown by pests of vegetable gardens, where the variation in environmental conditions is greater. It has been shown that under such conditions, insects which have short life cycles and possess a high degree of mobility in the imaginal phase are most likely to succeed as pests, particularly if they have a highly labile process of development. The group of insect species adapted to living on cultivated plants forms definite faunistic complexes. These complexes attain various degrees of development under different conditions of cultivation and in certain cases attain a measure of stability. The ecological analysis of insect pest fauna has hardly been begun as yet, although its practical importance is obvious.

Although of no great intrinsic interest, considerable data has been collected regarding the ecological characteristics of insects in relation to the effect on them of insecticides. Initially the problems of insect toxicology were treated merely from a physiological standpoint but it later became apparent that the physiological constitution of insects could be considerably altered as a result of adaptation to environmental conditions. Often such a change of physiological constitution takes place regularly (diapause, dormancy) but it may sometimes occur fortuitously and not as a result of recurrent environmental factors. Because of this it is impossible to work out for insects any general physiological standards or norms, which could be used as a basis for their toxicology. This deprives insect toxicology of a background of physiological principles and leads research workers to use empirical "norms" which are for the most part a statement of probability and only applicable to a given ontogenetic stage of the insect in question.

Ecological investigation has shown that among insects there is a very general reaction to injurious environmental factors (freezing, insufficient oxygen, etc.) and that this reaction is similar among different species and in different stages of ontogeny. The reaction is expressed biologically in a cessation of growth and development, and later in a sharp drop in the metabolic rate. The metabolism becomes predominantly anaerobic and is characterized by a high degree of stability toward deleterious agents, among which are included insecticides. This has been found to be the case for hydrocyanic acid, DDT and certain other toxic substances, according to Kozhanchikov, (1947a, 1953b). Because it is possible for insects in a physiologically depressed state to change rapidly into one of metabolic activity (and vice versa) under the influence of environmental conditions or in relation to a change of phase in the life cycle, insecticide application will only be effective when used under appropriate conditions and at a suitable ontogenetic phase. Moreover the specificity of an insecticide depends not only on the physiological but also on the biological cycle of development in an insect and it is further conditioned by ecological relationships. It is now known that populations of insect pests may become resistant to the effect of particular insecticides.

All these problems have a great practical importance, for on their solution depends the success of control measures against pests. As yet however, many of them have only just received the attention of ecological investigators and consequently their study is in its infancy.

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INSECT PATHOLOGY, ITS PRESENT AND FUTURE

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The science of insect pathology is becoming a more and more familiar feature of the world literature in applied entomology. I think it would be appropriate, therefore, to give a brief review of the contemporary state of this science and to indicate certain future trends in its development.

The conception of "insect pathology" includes the special application of pathological knowledge to insects: pathology being the science which studies the changes produced in an organism as a consequence of disease. A precise determination should be made of the causes, symptoms, etiology and epizootology of infectious diseases of insects in relation to the study of the changes produced by injurious, disease-carrying organisms. To this end, investigations into the general questions of microbiology and parasitology must be included, in as much as they are related to insects. The practical application of insect pathology lies in the biological control of insects, in which man utilizes insect pathogens as selective means of destroying pests. On the other hand, insect pathology has close links with medical and veterinary parasitology, microbiology and with general entomology and ecology.

The science of insect pathology may be said to have begun with the work of Pasteur, although the first description of a fungoid disease was given earlier by Bassi di Lodi (1835). Pasteur commenced his work as an investigator in this field in 1870 and gathered around himself a school of research workers, as a result of the practical need to study diseases of silkworms. One of these research workers was the famous scientist Il'ya Il'ich Mechnikov, a man eminently suited to this work because of his wide knowledge of invertebrate animals and his previous studies of parasitoses and inflammatory processes. On his return to Odessa to study the diseases of the grain beetle, Anisoplia austriaca Herbst., Mechnikov, in 1897, created a center for the study of insect pathology. His pupil I. M. Krasil'shchik continued the research in insect pathology and the biological control of insects over a period of 25 years from 1884. Unfortunately credit has not been generally given to the importance of this field of study having originated in Russia. Krasil'shchik was an enthusiast who wrote articles, delivered lectures and personally convinced his contemporaries of the possibility of controlling insects biologically and the benefits attending it. In this I. M. Krasil'shchik was ultimately successful, although it is necessary to remind ourselves that at that time the general use of insecticides was unknown. In 1884, at Smela, he propagated, in four months, 55 kg of pure spores of the mold Metarrhizium anisopliae and used this material, mixed with sand and dust, as a control measure against insect predators of beet in the state of Kiev. In experimental fields he obtained excellent results. Ten to 15 days after dusting the plants, 55-80% of the beet weevils (Bothynoderes puntiventris Germ.) on them had succumbed to the mycosis. Krasil'shchik intended to extend his treatment to the crop over a wide area and thus destroy beet weevils on a large scale but unfortunately a crisis in the agricultural industry prevented this plan being put into practice. In one of his letters to the French scientist Giard he describes the end of his efforts. "Here in our sugar industry there is a crisis, provoked by the overproduction of sugar beet. In such circumstances one cannot feasibly set about destroying the sugar beet weevil." It was difficult, therefore, at that time to put into practice the new ideas which would have facilitated the protection of plants and increased crop production. Toward the end of his life Krasil'shchik's study of insect pathology and biological control was transferred to the departmental institute. There he was joined by V. P. Pospelov, whose work, particularly in his later years was devoted almost entirely to these problems. With the death of Pospelov,

the organizing center for work in this field disappeared, although further studies in the discipline were later developed on a new basis. A decree was passed by the united assembly of the sericultural, agricultural, veterinary and plant protection industries (VASKhNIL) in December 1954, the execution of which should result in the development of this important scientific field. It is of interest to note that information on insect pathology has been collected together and forms the subject matter of several books e.g., there are some short chapters on this topic in Rubtsov's work; in a more detailed book by A. A. Evlakhova and O. I. Shvetsova (1953) and in Russian translations of books by A. A. Steinhaus, "Insect Microbiology" and "Insect Pathology".

Outside Russia, the study of insect pathology has proceeded more widely and intensively.

Work, similar to that of Krasil'shchik in using fungi as agents in the biological control of insects, was carried out by Snow (1890) and Forbes (1895-96) in the United States of America. In the initial period of investigation into possible methods for the biological control of insects, molds and other lower fungi were employed. D'Herelle's work published in 1911, brought about a change of outlook, for he described the successful use of Coccobacillus acridiorum in producing epizootics among locusts in the Yucatan peninsula and the successful control of these insects by this means in Yucatan, Guatemala and other places. As a consequence of this, research workers turned their attention to bacteria. Priority of success in this new direction of investigation lay with two co-workers in the Pasteur Institute in Paris—C. Metal'nikov and A. Paillot. Metal'nikov devoted his life to the study of immunity in insects and to their destruction by means of bacteria. He worked with a bacterium, now known as Bacillus cereus var. thuringiensis, one strain of which he used in many different parts of the world as an agent for the control of various pests, principally corn-borer moths and predators of cotton plants. His work commanded attention from scientists whose interests lay in the field of biological control in many different countries, in Yugoslavia by such men as Khorin and Khush, and in Hungary by Kotlan, workers who had for many years investigated the problem of insect pathology. Paillot made a special study of the fauna of southern France; in addition to his descriptions of various diseases he is well known for his monograph on "Insect infections" published in 1933, in which may be found an account of the diseases of insects peculiar to France. In America an analogous group of research workers was engaged in elucidating the problems of insect pathology as applied to agriculture and the U. S. Department of Agriculture gradually came to provide laboratories for the development of this work. Among American insect pathologists mention must be made first of G. F. White and R. W. Glaser. These two investigators have significantly advanced our knowledge of insect diseases and given to the study of this subject a strong economic bias. The name of White will always be remembered in connection with the bacteriology of insects, particularly of bees and of certain important agricultural pests. Glaser devoted considerable energy to the study of various diseases of insects and also to investigating the possibility of nematode worms as destructive agents against insects. An increasing interest in the diseases of insects was being developed at this time in other countries and centers of research came into being as a result. In Germany, for example, the research schools of Escherich and Zwölfer devoted their energies to the possibility of controlling important insect pests of timber. In Czechoslovakia, Yu. Komarek and V. Breindl began work on the polyhedral virus diseases of nun moths and went on to investigate polyhedral virus diseases in general; of their successors, O. Irovets turned his attention to protozoan parasites of insects. At the same time, research into insect pathology was begun in Canada, where the main emphasis was on diseases of timber-infesting insects.

It is interesting to note that despite considerable difficulty of studying insect pathology there has been a steady recruitment of workers to this discipline. This is just as true of the present time when chlorinated hydrocarbons, pyrethrins, organophosphorus compounds and other insecticides are extensively used, as of the earlier days before chemical poisons had been used against insects. In fact, it is since the Second World War that the most intensive study of insect pathology has developed.

Well to the forefront in this field is America, where a great many specialized laboratories for research in insect pathology have been built and equipped. In the USA, mention must first be made of the University of California laboratories at Berkeley, under the direction of Prof. E. A. Steinhaus; to these laboratories, perhaps more than to any others, belongs the credit of advancing the science of insect pathology at the present time, by means of practical research into fungal, bacterial, virus and protozoan disease of insects. In addition, there are in the USA other large laboratories at Beltsville, Maryland belonging to the U. S. Department of Agriculture and here active research is being carried out on the practical application of control measures against the Japanese beetle Popillia japonica Newm. (Dutky and co-workers), using, in the main, bacteria and nematodes; there are also regional laboratories at Lake Alfred in Florida (Fisher) and those of the Institute at New Haven, Connecticut (Beard). In Canada, there is a collection of laboratories devoted to the study of insect pathology at Saulte Ste.

Marie; here work is carried out in mycology, virology, bacteriology and protozoology of insects (Cameron, Bergold, Bird). There are research centers in the same field at Kingstone, Belleville and other places. The USA and Canada have already introduced a great many diseases and parasites from Europe in their efforts to control insect pests. In Central and South America there are no specialized laboratories devoted exclusively to insect pathology.

In western Europe a wide network of laboratories has been developed and in them active research into the problems of insect pathology is going on. England was rather late in the field in this respect. However, at the present time she has a well-developed virus research laboratory at the Monteno Institute, Cambridge (Smith, Xeros) and she utilizes the services of the Commonwealth Institute for the Biological Control of Pests, which is centered in Canada. There is a network of laboratories in Switzerland, West Germany and other countries. In France work in this field is carried out in two laboratories. The laboratory at the Pasteur Institute in Paris (Toumanoff) where microbiological problems are studied and the laboratories of the National Centers for Agricultural Research at Alès and Versailles (Vago). In West Germany, there are laboratories for the study of insect pathology at Darmstadt (Franz, Krieg), where work is being conducted on fungi, viruses, bacteria and protozoa. In Italy, a study of insect diseases features in the program of research carried out by Sericulture Research Stations at Padua (Masera), Rimini and Florence. Switzerland prossesses a laboratory at Zurich which specializes mainly in the study of viruses attacking pests of timber. In addition to these laboratories, there are in western Europe various other institutes in which a certain amount of research into the problems of insect pathology is being conducted.

The Peoples' Democratic Republics also feature among those countries with specialized laboratories for the study of insect pathology, particularly that of the Biological Institute, Czechoslovakian Academy of Sciences at Prague. This laboratory is concerned with investigations into mycoses, bacterial infections, virus diseases, and diseases caused by protozoa, parasitic worms and mites. Recently a similar laboratory has been founded at Belgrade.

In the Soviet Union, there is an important laboratory concerned with insect pathology at the All-Union Institute for Plant Protection in Leningrad (Evlakhova, Shvetsova), where research into virus and fungal diseases of insects is being carried out. In addition, there are, within the USSR, smaller centers of research in this field at Irkutsk (Talalaev), Voronezh, Tashkent, Kiev and elsewhere (associated with sericulture and agricultural institutes.) However, as yet eastern Europe has not been caught up in the rapid expansion of research facilities in this field.

Throughout the rest of the world apart from the territories mentioned, it is only possible to name a few laboratories in which specialized research into the problems of insect pathology is going on: there is the University at Kyushu in Japan (Jamafuji), the University of Honolulu, Hawaiian Islands (Tanada) and that of Adelaide in Australia. Further work is being carried out at Agricultural Research Stations, but these cannot be enumerated in detail here.

In 1945, few of the laboratories mentioned in my brief survey were in existence. That so many have sprung up in countries where research is dependent on capital investment and where it is expected to pay dividends in furthering increased productivity is ample evidence of the economic importance of insect pathology.

What are the problems which we expect insect pathology to solve? We have tried to answer this particular question before drawing up our research program at the Insect Pathology Laboratory within the Biological Institute, Czechoslovakian Academy of Sciences. In our opinion, the initial tasks before insect pathologists are as follows:

1) to describe insect pathogens, the etiology of the diseases produced by them, and the effect of the pathogens on the reproduction and variability of the insect host;

2) on the basis of information regarding the infections of insects to be able to make an accurate prognosis of mass multiplication in any given insect population with a view to determining the best time to introduce the appropriate control measures and to be able to predict what effect biological and chemical methods of control will have on the general biocoenosis to which the insect population belongs;

3) to explore the possibility of introducing new pathogens of insects from abroad with a view to controlling pests by this means, and to spread the range of indigenous pathogens to areas where they so far play no part in controlling native pests;

4) to use what information, we already have regarding the movement of microorganisms and their transference to insect populations, with a view to assessing the importance of the various elements in a given biocoenosis as possible vectors in the spread of disease to man and domestic animals;

5) to utilize what information is acquired to protect useful insects especially silkworms, bees and other plant pollinators, together with entomophagous predators.

Which of these general points are covered by the various aspects of our research program?

Description of Pathogens

The significance of this point is quite clear. In every scientific discipline, in which there is a desire to add to the knowledge already gained, it is necessary first of all to collect factual information; not only as a basis for the induction of theoretical hypotheses, but also to provide us with information whereby we may test our hypotheses. Although much has already been accomplished in the study of insect parasitic diseases, we are still far from having a complete picture of all aspects of this subject. Probably the most complete study so far is that of mycoses (fungal diseases) of insects, as on the one hand there are few species involved and on the other, they have been studied for a long time. In spite of this, certain problems connected with fungal diseases of insects still await explanation; for example those connected with the virulence of the fungal pathogen and the powers of host resistance to it; the question of how certain fungi maintain themselves in nature, particularly those which so far cannot be successfully grown in artificial media; together with others. A great many bacteria which attack insects have been named and described; yet the majority of these species cannot be fitted into any contemporary scheme of classification because of deficiencies in their descriptions and a lack of knowledge of their affinities. Moreover, we know practically nothing regarding the frequency with which the various bacteria occur in their hosts or of the normal microflora of the host intestine in relation to that which arises under pathological conditions.

Our knowledge of the fluctuations in members of different microorganisms in a single biocoenosis is far from complete, as is our information with respect to the influence of food and climate on the microorganisms in biocoenoses, together with other basic facts of experimental epizootology. It should be stressed that contemporary ideas regarding immunity in insects are largely incorrect, for they are based on false analogies with the situation in warm-blooded animals. The virus infections of insects constitute a large field of study. This field includes, on the one hand, those viruseswhich are peculiar to insects and, on the other, viruses which are transmitted by insect vectors to other hosts. The polyhedral viruses are especially favorable objects for the study of developmental processes, and for the study of the effect of this type of pathogen on host tissue, because they form visible agglomerations at various stages of their developmental cycle and these can be observed as rounded, whitish masses. Vertebrate viruses transmitted by insect vectors need to be studied intensively both in their relationship to insects as hosts and from the point of view of their distribution in biocoenoses and in species of animals not directly involved in their transfer to vertebrates. As regards the protozoan parasites of insects, it is possible to predict that in the future many interesting facts concerning their activities and pathogenicity will be discovered. From the information available at the present time, it would seem that every species of insect has at least one protozoan parasite which is peculiar to it. Thus we have here a fruitful field of research with almost unlimited possibilities.

Metazoan parasites of insects are not particularly numerous but our knowledge of those which do occur is very scanty. For example, our knowledge of the numerous nematodes which affect these hosts is very incomplete; similarly very little work has been done on the acarines which attack insects. We find that in the majority of cases all that is available in this field consists of ancient and inadequate descriptions of the adults, together with some information on the developmental stages but of their general pathogenicity toward the insect host and of their relation to the parasitic biocoenosis as a whole, practically nothing is known.

It is only possible to give a full account of a particular insect disease in relation to a clearly defined climatic region; as yet we have insufficient material to do this and we cannot therefore make full practical use of the information we possess.

Prognosis of the Growth of Insect Populations

We believe that a prognostic determination of the development of insect populations, based on a knowledge of the frequency of occurrence and the virulence of pathogens, is a more valuable exercise and serves a more practical purpose than active interference in the life of biocoenoses without knowledge of the possible

consequences. Such a prognosis provides a basis for evaluation the possibility of mass multiplication leading to plague proportions in insect populations and also of their return to normal level. It is difficult to see why in the past investigators actively interfered with insect biocoenoses involving pests, without knowing anything about the relationships between insect diseases and the population as a whole. Without a knowledge of the normal spread of infection in a given population, or of the percentage mortality during infection, or of the effect of abiotic factors on the spread of the disease it is impossible to choose a suitable pathogen for the destruction of the pest. This is particularly true of an absence of knowledge regarding the transmission of a pathogen from one host to another. It is important that continuous and prolonged observations should be carried out on insect populations unaffected by man prior to prognosis. It is unfortunate that most entomologists have not even an elementary knowledge of insect pathology and consequently most infections among insect populations are either overlooked completely or attributed to the normal death rate of the species or to the effect of abiotic factors.

As a result of all this, insect pathology has,in the past,been deprived of much valuable data and moreover, a certain amount of recent data accumulated by specialists is incorrect because they have failed to take into account the importance of infection as a factor which cannot be controlled with precision. Insect pathologists have tended to ignore the importance of the time factor in their investigations of diseases; this deficiency we have attempted to eliminate in planning research at this Institute. Older data on the mass multiplication of the nun moth (Liparis monacha) and other pests tends to suggest that a "plague" is always terminated as a result of the effects of polyhedral virus disease and it then takes several years for the population of the moth to approach the danger level (for example, the 11-year cycle). From a knowledge of the incidence of disease and its local spread, as determined by the analysis of death rates among pests, it is possible to predict both the occurrence of mass multiplication among harmful insects and determine the time of onset of disease. There is no need,therefore, to control such pests by chemical means (which only impedes the development of epidemics) but by strengthening and reinforcing the infection during the critical period of its development it can be stopped up to pandemic proportions and thus exterminate the pest over a wide area with considerable economic benefit. One can compare the use of insecticides in biocoenoses with the taking of narcotic drugs by mankind: both result in an increased tolerance with a need to step up the dose; the use of insecticides favors the multiplication of resistant strains of the pest at the expense of the diminution in the numbers of its natural enemies (entomophages) and thus we have a vicious circle.

From our comparatively brief experimentation it is possible to quote certain examples demonstrating the possibility of prognosis.

In 1945, we repeatedly came across large numbers of the greater Lucerne weevil, Otiorrhynchus ligustica L. on sugar beet crops and the incidence of this pest increased reaching a maximum in 1949. Careful examination revealed that the majority of the beetles were infected with the microsporidian Nosema otiorrhynchi, and that this pathogen affected all organs of the body, and ultimately caused the premature death of the host; moreover the presence of the microsporidian in their tissues caused the weevils' susceptibility to DDT to be increased tenfold. A gradual increase of the infection caused the numbers of the pest to diminish, so that the weevils soon became quite rare and the damage caused by them became economically negligible. The microsporidian infection, which is transmitted by way of the eggs and larval forms, could be regarded as the cause of the gradual reduction in numbers of the pest.

Another case of a similar kind occurred at the time of storing walnuts, a process which took place in open sheds with the nuts stacked into piles one on top of the other to a height of 13 m. In these piles, Plodia interpunctella Hb. made its appearance; it covered all the stacks with a silken paper-like webbing up to 1.5 cm. thick. In open sheds fumigation could not be used to destroy the pest; all that could be done was to remove the silken webbing from the piles and clean the nuts by rubbing them on new sacking. This latter process however, proved to be too expensive to carry out. Investigation of the webworm population showed that 45% of the caterpillars were infected by a schizogregarine, Mattesia dispar. It was decided therefore to do nothing at all with the stored nuts. From the second (summer) generation an enormous number of caterpillars emerged, but in these the infection developed so rapidly that most of the caterpillars died in their third instar. The paper-like covering of silken webbing was studded with dead and dying larvae, lying in several layers. During the winter the stacks were examined; it was found that despite the thick covering of silken webbing, damage to the nuts was negligible.

Another similar incident was observed in 1953, when in the Czech lowlands a plague of silver γ -moths occurred in sugar beet fields, with the possibility of considerable damage to the crop. However the older first

generation larvae were found to be strongly infected with the fungus Entomophthora virescens. The second generation was so markedly reduced in numbers that the sugar beet crop suffered little damage.

Other entomophilous fungi appeared in 1955 on sugar beet aphids. Insecticides had previously been employed against outbreaks of aphids on sugar beet crops. In a control plot, it was established that practically all the aphids were destroyed by the Bauveria infection and that it was therefore unnecessary to employ insecticides.

These selected examples from among a great number of more complex cases show how diseases, suitably encouraged, may do away with the necessity of using other control measures against pests.

Store houses and cultivated fields are however comparatively transitory biotopes compared with forests, gardens and meadows. Only in these latter biotopes can we investigate the various factors which regulate populations of pests over a number of years. Such research has already been commenced.

Artificial Control of Insect Populations

In order to accomplish this, careful preliminary investigation is necessary. Such artificial control can be of two kinds. On the one hand there is the "short-term" type of control, in which we attempt to destroy a single generation or the generations in one particular year, with the consequence that the infection is not carried over into subsequent years, as all the individuals in the biotope have either died or become immune to it. The second kind of control is the "long-term" type, in which we introduce into the biocoenosis a new infection, which on establishing itself, keeps the normal annual population of the pest at a low level, by destroying many of them each year.

The "short-term" method of controlling insect populations by means of a single infection is not a difficult matter and has been used successfully on many occasions. Where a fungus is to be used as the source of infection, it is simplest to raise large quantities of spores and then disseminate them over the area occupied by the pest. Provided that a sufficiently large quantity of spores are employed, success can usually be guaranteed. Experiments carried out in Czechoslovakia have demonstrated the possibility of using fungal spores for the successful destruction of Colorado beetles, beet moths, and greenhouse scale insects (Kral, 1954; Samsinakova, 1955). With bacteria constant results have been attained against a wide range of pest species; Bacillus thuringiensis is usually successful in controlling the Japanese beetle, Popillia japonica Newm. in the USA. In certain cases the result depends on the intensity of spore formation in the particular strain used. It is necessary to plan and execute the control project with extreme care as so many factors are involved; for example, the virulence of the microorganisms, the dosage and the resistance of the host insect all play an important part in determining whether or not the control technique will be successful. It is possible that in the future we may be able to change the normal bacterial flora of the insect gut into a pathogenic one by means of chemical substances.

Viruses are more complicated subjects to use as control agents than fungi or bacteria. Together with that infection which is produced immediately on application of the polyhedral virus and which is of comparatively short duration, latent infections may also arise as a result of the initial treatment; these may persist for several years and ultimately destroy the whole population, if they become sufficiently virulent. The work of Steinhaus on Colias philodice eurytheme (1950) or Bird on Neodiprion sertifer Geoffr. (1953) demonstrates the possibility of using viruses for the biological control of insect pests.

In recent years a considerable measure of success has been attained within a single generation of particular pests using protozoa as control agents. Positive results have also been attained by infecting the hibernating generation in the autumn so that the disease is carried over to the first generation of the following year (Weiser, Weber, 1955, 1956). Among the Metazoa, good results have been obtained in the USA, using the nematode Neoaplectana glaseri, which can be cultured in the laboratory; this nematode has been used for the control of the Japanese beetle.

In experiments carried out over many years representatives of many different groups have been used. It has been demonstrated that the concentration of fungal control agents falls to an imperceptible level, unless favorable conditions are provided for their spread. This has been confirmed by Hergula (1930, 1931) using metarrhizium against Pyrausta nubilalis Hb. and by many other experiments. Trials using bacteria have all given rather disappointing results; Bacillus thuringiensis had suffered so great a decrease in activity by the second generation as to be without effect on the host. It would seem that few bacteria can be employed successfully in the

biological control of insects, except for such species as Bacillus popilliae which is liberated onto the soil in such quantities from the corpses of its victims that other larvae are bound to be infected. Exceptionally predatorial or cannibalistic species may take into their bodies cultures of microorganisms contained within their victims (as has occurred in the case of Coccobacillus acridiorum). Rickettsia melolonthae is similar to Bacillus popilliae in being able to disperse itself actively and found fresh pockets of infection; this former species is locally distributed throughout Europe and infects May fly (cockchafer) larvae.

For all insect diseases there are definite focal points of distribution. Single cases of infection or quite healthy populations may occur in close proximity to other populations which are more or less strongly infected. The introduction of "domesticated" species (e.g., mulberry and oak silk moths) into an area, may bring to light reservoir infections which previously existed as focal infections among closely or distantly related wild species. A similar situation may arise when pests have been introduced accidentally into an area. Our own investigations have revealed that the American moth, Hyphantria cunea Drury was free from diseases when first introduced into Europe, but this species has now acquired parasites and pathogens characteristic of European lepidoptera. For example, Hyphantria cunea in Europe, is parasitized by Thelohania hyphantriae, a microsporidian normally parasitic in the brown tail moth; other pathogens acquired by this species are Nosema musculonis from Lymantria dispar L. and Nosema minor from Euproctis chrysorrhoea F. Up to date, Hyphantrea cunea does not appear to have acquired any polyhedral viruses, fungal or bacterial infections. In connection with this problem of the acquisition of "foreign" parasites, it is appropriate to apply the hypothesis and laws established by E. N. Pavlovskii in relation to endemic foci and natural reservoirs of human disease. The aim of those working on the biological control of insects is to elucidate the laws governing the spread of focal infections in insect populations and to discover the way in which environmental factors favor the increase or decrease of such infections.

Among the other problems of biological control is that of the introduction of specific diseases. There are many cases on record of pathogens having been employed to destroy pests, previously introduced into a particular country. The biological control of the sawfly, Gilpinia hercyniae Hart. is an obvious example. This sawfly was accidentally introduced into Canadian forests, where it spread throughout the whole of the fir forests of eastern Canada, doing an enormous amount of damage. In Central Europe e.g., Czechoslovakia and Germany this species of sawfly is widely distributed, but here it forms part of a balanced biocoenosis and its members are kept in check by many parasites and predators. From 1936-38 a Canadian expedition visited Czechoslovakia and neighboring states, in oder to discover and collect the parasites attacking this sawfly. According to a government report, more than 392,000,000 parasites of this pest were obtained and liberated in the Canadian forest where Gilpinia hercyniae had established itself. In addition, 15 species of entomophages (predators of the pest) were discovered in Canada itself, and the controlling effect of this formidable array fully justified expectations. The presence of polyhedral virus diseases in G. hercyniae Hart. were observed in the 1936-38 expedition in Czechoslovakia. However, the disease did not in any way affect the parasites and predators of the pest and therefore it was not considered necessary to alter the proposed program of introduction. In consequence, the entomophagous parasitoids of G. hercyniae were sent to Canada in caterpillars, some of which were suffering from polyhedroses. The result of this was seen in 1941 when Balch reported the presence of an undescribed polyhedral virus in G. hercyniae in Canada. In subsequent reports Balch showed that the extension of the disease was associated with a reduction in the numbers of the pest. The collection of parasites and predators of G. hercyniae was not resumed after the war, as polyhedral virus disease had stamped out this sawfly as a pest in Canada.

No better example could be given than the above, of the need for a fundamental study of the role of various infections on the mortality rate and natural regulation of populations before attempting the introduction of new agents for the biological control of pests.

So far very little is known regarding the circulation of microorganisms in biocoenoses. Thanks to the study of E. N. Pavlovskii on natural reservoirs of infection, we have some information regarding the circulation of certain pathogens of animals and man, but that is all. Even in this particular field much more work is needed, for in spite of the more rapid accumulation of knowledge, by statistical methods and methods based on frequency determinations of host transfer, there is still a need to demonstrate that transmission of infection is not a thing of chance and this can be done only by investigating the manner of transfer of both pathogenic and nonpathogenic microorganisms. There is also a need to investigate the relationship between the parasite- coenosis of the larval form and that of the adult in vectors such as fleas, mosquitoes, flies etc., which feed on different

diets at various stages of their development. We know very little of the mortality rate and the causes of mortality among the parasites of man; these require investigation. Moreover, it is desirable to have a precise knowledge of the specific microflora and microfauna of animals belonging to the various taxonomic groups.

It has been demonstrated that the microflora and microfauna of different hosts are highly specific and that the relationships between them are influenced more by taxonomic affinities than similarity of diet; transfer of microorganisms does occur between hosts of different species and the possibility or otherwise of this taking place provides a valuable clue to possible relationships between hosts. Insects are particularly suitable subjects for research in experimental epizootology, for they can be reared in large numbers and thus it is not particularly difficult to study the direction of an experimental epizootic in the laboratory. Unfortunately this aspect of insect pathology has been universally neglected despite the fact that research along these lines would solve many epidemiological problems.

In studying the fundamentals of insect pathology and epidemiology a beginning might be made with the diseases of useful insects. Work has been done on possible methods of controlling disease in silkworms and bees, but there is a dearth of information regarding the diseases of other useful species e.g., plant pollinators, entomophagous and carnivorous species which are of economic importance in various ways. The biotope and diet of the silkworm is very carefully regulated and hence it is not difficult to control the diseases of this species; bees, on the other hand, are more independent. They can pick up infections in many places outside the hive, and such infections are difficult to control. Therefore in the struggle against disease the apiculturist has to carry out research in 2 directions: toward the discovery of effective therapeutic and antiseptic agents capable of destroying pathogens in the bee and in the hive and toward the recognition of places where infections originate and the intermediate hosts of pathogens occurring outside the hive. Only by combining curative and prophylactic measures, can the apiculturist obtain more favorable results in ensuring the health of his stocks.

From among the previously mentioned theoretical and practical considerations, (which may have seemed lengthy to the uninterested reader, but which are nevertheless incomplete) one definite conclusion emerges; namely that the application of insect pathology to practical problems has already achieved some considerable success, which augurs well for the future. The success which has already been achieved stems from the direct application of fundamental research and prognosis. In order to develop fully other important aspects of insect pathology, international cooperation is necessary. A single research center for insect pathology in Central Europe is able to serve an area approximately 500 km^2. Where more uniform conditions prevail this area might be increased to 1000 km^2 or more. The aim of such centers is to gain acquaintance with the common pests of the area they serve and the diseases which attack these pests. Each center should employ the most recent techniques and disciplines of contemporary science and in order to do so, there should be a constant exchange of ideas between the staffs of various centers. Research teams at various centers would be chosen in relation to local needs but in addition there should be a nucleus of experts—mycologists, bacteriologists, virologists, protozoologists, etc., to deal with special problems. Ideally, laboratories of the kind described above should be supplemented by other laboratories for the study of predators and entomophagous species and also for the study of insecticide action. There is need for international cooperation in projects of this kind, in order that workers in different countries might collaborate over problems connected with the introduction of infections from one country to another and the distribution of pathogens of important pests over large areas. To attain such ends, it would be necessary to unify the control of insect pathology laboratories, particularly those in countries which are similar geographically (this, however, does not preclude the possibility of using pathogens from temperature countries to control pests in the tropics and vice versa). It is only under conditions of close collaboration that a wide network of insect pathology laboratories, capable of working on the previously suggested lines, could be set up and thus resolve the many problems so urgently awaiting solution, in a reasonably short time. This collaboration would undoubtedly lead to closer cooperation in the broader fields of applied medical and agricultural entomology thus freeing these sciences from a narrow political and insular outlook and allowing them to be viewed against broad ecological and zoogeographical backgrounds. The Soviet Union and Peoples' Democratic Republics must look forward with confidence to the accomplishment of such aims in the general advancement of science.

STRUCTURE OF THE INSECT BRAIN AT SUCCESSIVE STAGES OF POSTEMBRYONIC DEVELOPMENT

II. THE CENTRAL BODY*

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Position, composition and connection of the central body. A central body was found in the brain of all the adult insects studied in this respect. It is located in the median part of the protocerebrum and is surrounded from practically all sides by the neuropile of the main protocerebral lobes. In the brain of insects with well-developed mushroom bodies, the central body is bounded laterally by the stalks of the latter, and beneath by their median branches.

As a rule, the central body can be divided into two parts, a larger upper and a smaller lower; the lower part appears to be partly embedded in the upper. In a number of cases the latter is divided into several large glomeruli arranged in fanwise manner, which was the reason for the original name of this center "facherformiges Gebilde" [Dietl, 1876]. The lower part seldom shows such a clear division into glomeruli and is usually penetrated only by tracts of nerve fibers.

Some authors describe the central body as a center of associative nature, which does not have nerve cells of its own, directly connected to it [Böttger, 1910; Kühnle, 1913; Buxton, 1917]. Such a view is found even in some textbooks [Snodgrass, 1935; Shavanvich, 1949]. But Viallanes [1887] had already described a bulky mass of nerve cells in the pars intercerebralis of the brain of locusts and these cells were connected with the central body, while Kenyon [1896] had distinguished in bees two types of neurons ("5" and "6") located in the same part of the brain and sending out processes in the form of a commissural tract along the posterior surface of the central body. From these processes, according to the last author, dendrites branched out into the fibrous matter of the central body, the mass of these dendrites forming interlayers between the glomeruli of its upper part. Similar cells connected with the central body were described by Baldus [1924] in the case of dragonflies. The central body of Periplaneta [Hanstrom, 1928] is also connected above and behind with the nerve cells of the protocerebrum. A connection of the central body with the neurons located in the pars intercerebralis has been found also in Dytiscus [Holste, 1923], Panorpa [Bierbrodt, 1943] and in many Polyneoptera [Hanström, 1940].

Moreover, Kühnle [1913] had already described in Forficula a so-called "posterior bridge between the accessory protocerebral lobes and the central body," and which had the form of a strand of commissural fibers uniting the accessory protocerebral lobes of each half of the brain and underlying the lower part of the central body. A close connection between the latter and the accessory lobes of the protocerebrum was also found in Dytiscus [Holste, 1923; Jawlowski, 1936] and in Panorpa [Bierbrodt, 1943].

In connection with the fact that the central body in more or less unmodified form was found, as already mentioned, in all the insects studied and had connections with most of the sections of the brain, it may be assumed that it, like the mushroom bodies, is an important association center, but as distinct from the latter, an association center

* For the first part of this work, dealing with the development of the mushroom bodies, see Entom. obozr. 36, 2 269-284 (1957).

of lower order. Of interest in this connection is the above-mentioned close link of the central body with the accessory protocerebral lobes, which, like the central body, find their greatest development in insects with relatively simple behavior (for instance, Lepidoptera). In Bretschneider's opinion [1913], in forms with much more complex behavior (for instance, Hymenoptera Aculeata) the functions of the central body are partially transferred to the mushroom bodies, and hence its degree of development is inversely related to the degree of development of the latter.

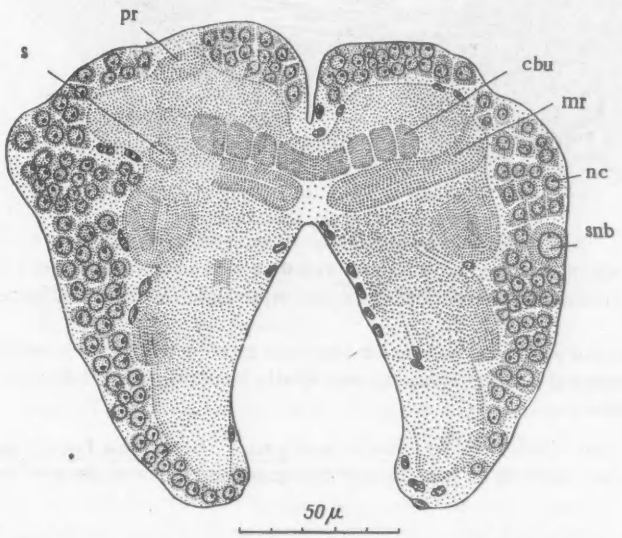

Fig. 1. Head of newborn larva of Tenebrio molitor L. Frontal section. cbu—Upper part of central body; mr—median root of mushroom body; s—stalk of mushroom body; pr—posterior root of mushroom body; nc—nerve cells; snb—solitary neuroblast.

The central body in the preimaginal stages of ontogenesis. The central body shows great variation both in the times of its appearance and in its degree of development in the preimaginal period. For instance, in newborn cagerpillars of Pieris brassicae L. [Hanström, 1925], Ephestia kuhniella Zell. [Schrader, 1938] and in newborn larvae of Calandra oryzae L. [Murray and Tiegs, 1935] it is still absent. According to my investigations, the central body is also absent in newborn larvae of Musca domestica L., Anthonomus rubi Hbst. and Apis mellifica L. On the other hand, from my observations, the central body is already in existence in newborn larvae of Tenebrio molitor L., Chrysopa sp., Ascalaphus sp., Antheraea pernyi Guér. and Culex pipiens L. At this time it consist only of the upper part, which is very drawn out across the brain. In the mealworm (Fig. 1, cbu) and in the caterpillar of the tussur moth the upper part of the central body is divided into a number of large glomeruli. In the other larvae it is represented by a homogeneous band of neuropile. The lower part at this time is still absent. Its place is occupied by a small tract of commissural fibers, which lies directly under the upper part and often cannot be distinguished in sectioned material.

If we compare insects which possess a central body at the time of emergence from the egg with those which do not possess one at this time, we find that most of the representatives of the second group are either blind or have poorly developed stemmata. This comparison, in my opinion, corroborates Bretschneider's [1914] opinion that the degree of development of the central body is directly related to that of the organs of vision and their centers.

As regards fully grown larvae, the central body is present in the brain of the vast majority of them. The only exceptions are Ephestia kühniella Zell. [Schrader, 1938] and Oryctes nasicornis L. [Jawlowski, 1936], in which it does not appear till the pupal period. The central body of fully grown larvae, like that of newborn larvae, is

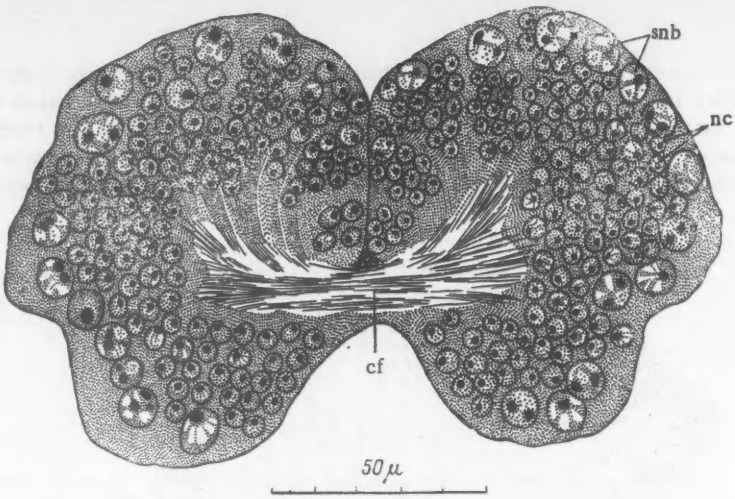

Fig. 2. Brain of newborn larva of Apis mellifica L. Frontal section. of Commissural fibers uniting the two halves of the brain. Other letters as in Figure 1.

distinguished by being drawn out across the brain and by the poor development of the lower part. Observing the incomplete structure of the central body in larvae, authors usually record that it still does not reveal any division into two parts at this time.

In two species of May flies which I studied (Ephemera vulgata L., Heptagenia fuscogrisea Retz.) there was no central body in the brain of newborn larvae. Its appearance and development was confined entirely to the postembryogenesis.

In Polyneoptera the central body is already present in the embryonic period [Viallanes, 1891]. In newborn nymphs at my disposal (Metrioptera sepium Jers., Gryllus domesticus L., Calliptamus italicus L., Ameles taurica B. Jak. and Dixippus morosus Br.) its structure resembled the imaginal type (Fig. 9c). During postembryogenesis in these insects the central body merely grows and changes only slightly in form.

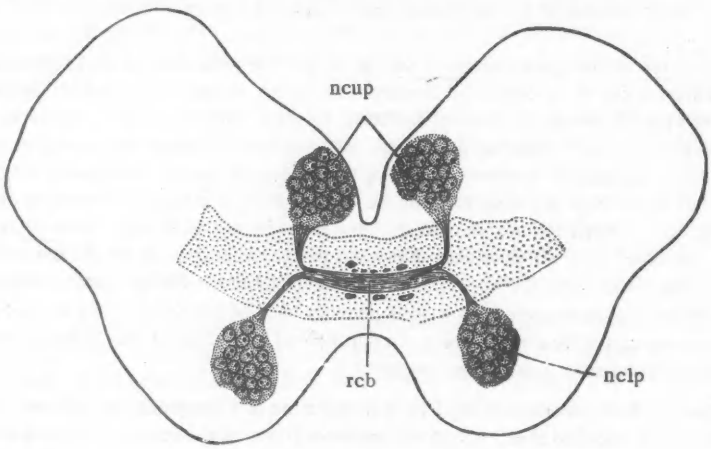

Fig. 3. Schematic structure of median part of protocerebrum of 3-day-old larva of Apis mellifica L. rcb—Rudiment of central body; ncup—nerve cells of upper part of central body; nclp—same of lower part.

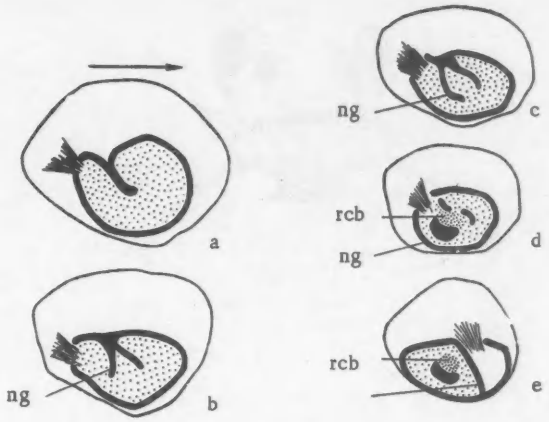

Fig. 4. Schematic series of consecutive sagittal sections of the median part of the protocerebrum of a 5-day-old larva of Apis mellifica L. (a—Most lateral section). rcb—Rudiment of central body; ng—neuroglia.

The development of the central body in Heteroptera apparently proceeds in a similar manner. In any case, in the newborn nymph of Palomena,I could make out that its structure was the same in basic features as in the adult bugs.

In certain aphids, however, of the genus Pemphigus [Pflugfelder, 1936-1937] to be precise, the central body does not form part of the brain of the newborn larvae. In the wingless female parents, which are provided only with larval three-faceted eyes, it remains throughout the whole individual development in the form of a tract of commissures connecting the two halves of the brain. In individuals of the winged generations the central body also consists initially of commissural fibers which connect, on one hand, the lateral parts of the protocerebral lobes, where the cells producing them are located, and on the other hand, the accessory lobes of the protocerebrum. At the site of the first commissures there arises the upper part of the central body, and at the site of the

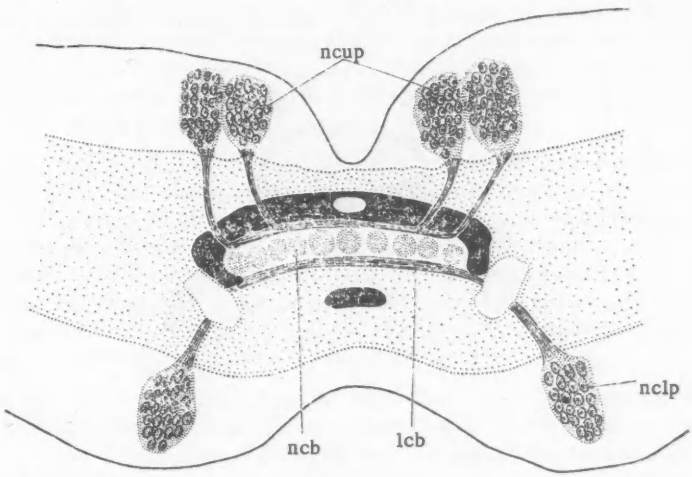

Fig. 5. Schematic structure of median protocerebrum of 6-day-old larva of Apis mellifica L. ucb—Upper section of central body; lcb—lower section of central body. Other letters as in Fig. 3.

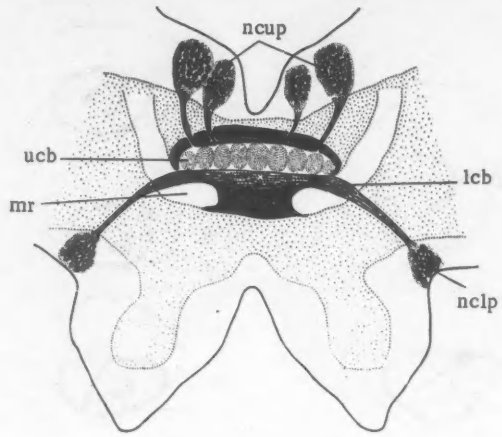

Fig. 6. Structure of median protocerebrum of 2-day-old prepupa of Apis mellifica L. (schematic). Letters as in Figs. 1, 3 and 5.

second—the lower part. Here the lower part from the very start contains punctate neuropile in its composition and is larger than the upper part. Later, however, the ratio of the sizes of the parts changes in favor of the upper part. A considerable growth of the latter is observed particularly in the period of differentiation of the compound eyes. In adult aphids the upper part considerably predominates over the lower part. From a consideration of the development of the central body during ontogenesis Pflugfelder concluded that "the central body is simply a developed system of commissures, the anterior part of which unites the two main lobes, and the posterior part—the two accessory lobes of the protocerebrum" (p. 69). However, it is difficult to agree with this, since the behavior of the fibers in the central body is of quite a different nature from that in the commissures [Bretschneider,1914; Hanstrom, 1928].

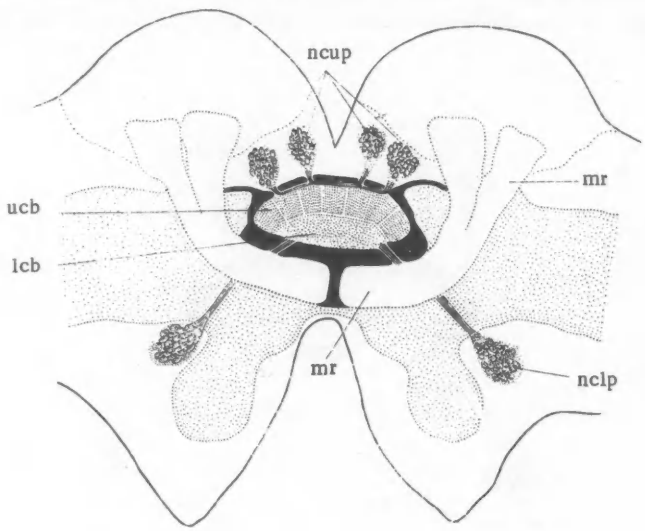

Fig. 7 Schematic structure of brain of 1-day-old pupa of Apis mellifica L. Letters as in Figs. 1, 3 and 5.

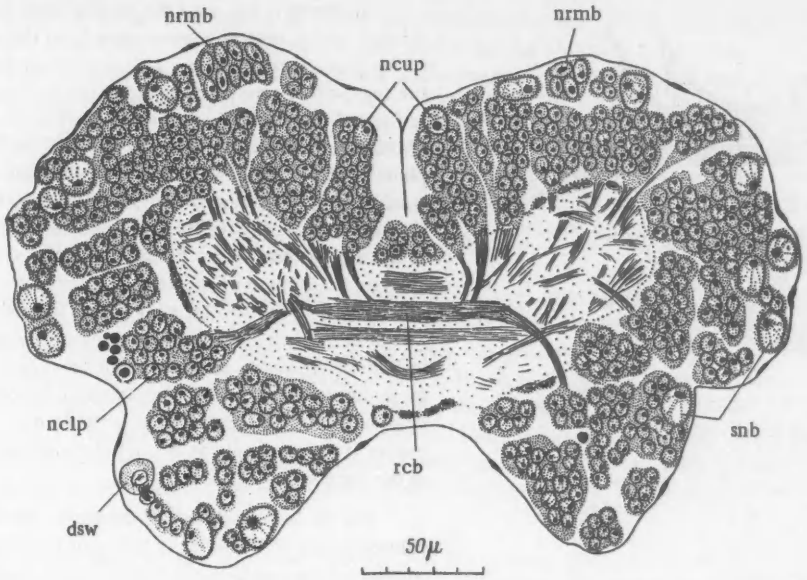

Fig. 8. Frontal section of brain of embryo Gryllus domesticus L., when yolk occupies about $^1/_4$ of the egg above the head. dsn—Division of solitary neuroblast; nrmb—neuroblasts of rudimentary mushroom body. Other letters as in Figs. 1 and 3.

Since the course of development of the central body in aphids did not coincide with that observed in larvae of Oligoneoptera, I undertook a fuller investigation of the course of development of this center in holometabolous insects. The object chosen for study was Apis mellifica L., the central body of which develops entirely in the postembryonic period. For purposes of comparison I also traced the development of the central body in Gryllus domesticus L., a representative of the Polyneoptera, although its central body is already present in the embryonic period.

Development of central body in Apis mellifica L. As already stated, the newborn larva of the honeybee still does not possess a central body as part of its brain. At this time the transverse band of fibrous neuropile connecting the two halves of the brain is very fine and consists of fibers running parallel to one another (Fig. 2, cf). The structure of the median region of the protocerebrum is still the same in larva 1 day older. On the third day of life of the larva, however, the following takes place.

The neuroglial cells, found up to this time only on the surface of the fibrous matter, begin to grow deeply into it from the dorsal surface. This results in the formation of a layer of neuroglial cells, which in the median region of the brain separates a small frontal portion of the fibrous matter, the so-called "front connection", from the remaining mass. At the same time the structure of the fibrous matter itself alters. Whereas previously the fibers of the commissural tract in the median part of the brain were uniformly distributed, we begin to distinguish in the three-day-old larvae one bundle with a particularly dense arrangement of fibers, this bundle being bounded in front by the above-mentioned layer of neuroglial cells penetrating inside the neuropile, and separated behind from the remaining mass of fibers by single neuroglial cells (Fig. 3, rcb).

The fibers of the dense bundle are formed from the outgrowths of nerve cells collected in rather symmetrically disposed groups. One group of cells is located in the forepart of the brain between its protocerebral and deutocerebral sections (Fig. 3, nclp). These groups of cells each send a strand of fibers toward the median bundle from below and from the front. The other cells are situated in the hindpart of the pars intercerebralis. In the early stages of development they are represented by one group in each half of the brain (Fig. 3, ncup). The fibers of the cells of these groups extend downward, forward and into the middle, until they reach the lateral margin of the dense bundle. They then form part of it and extend into the upper hindpart of the bundle. The lateral margins of the latter are a little nearer the center than the sites of branching of the developing mushroom bodies into a median and posterior root.

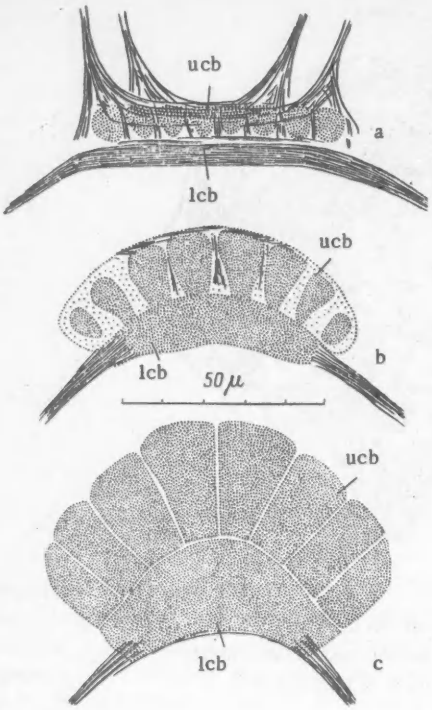

Fig. 9. Stages of development of central body in Gryllus domesticus L. a—Early stage of development; b—later stage; c—central body of newborn nymph. Other letters as in Fig. 5.

In the next two days the bundle itself becomes thicker, and it separates even more from the neuropile of the protocerebral lobes. This separation results from the ingrowth of new portions of neuroglia from the dorsal surface of the neuropile. The ingrowth begins at two symmetrically situated points, a little of the median plane of the brain. The neuroglial cells extend downwards and into the center until, finally, they arrive behind and a little below the dense bundle (Fig. 4, a-e). In the central part of the dense bundle the neuroglial cells on the surface of the neuropile still do not communicate with the similar ones within the fibrous matter. At the same time the layer of neuroglial cells situated in front of the dense bundle spreads out. As a result of these processes the latter is compressed between the two strips of neuroglia. Connection with the other fibrous matter is retained only at the upper and front lower parts of the bundle (Fig. 4, e, rcb).

On the last, sixth day of the larval period of development the still further isolation of the bundle is accompanied by considerable changes in its structure (Fig. 5, ucb. lcb). Between the strands of fibers which extend only along the fore and lower edge of the bundle, there now lies a strip of dense punctate neuropile, divided into several large glomeruli. The number of the latter reaches ten. These glomeruli represent only the upper part of the central body, the lower part at this time being still represented by fibrous neuropile.

In the pars intercerebralis of the fully grown larvae we can now distinguish not two, but four symmetrically situated groups of nerve cells which send out processes into the central body (Fig. 5, uccb).

Thus, the central body of the final-day larva is very similar in form to that of the imago. In the larva it is drawn out across the brain and weakly produced dorsally. At this time the central body of the bee is similar in structure to the central body of other larvae of the Oligoneoptera.

Later, as a result of the growth of the glomerular neuropile of the upper part and the homogeneous neuropile of the lower, the central body begins to assume its final form (Fig. 6, 7, ucb. lcb). Its neuropile becomes more dense and the contribution of the commissural fibers to the composition of the central body becomes less and less. In a similar way the contribution of the neuroglia decreases in the pupal period. In old pupae and in the imago the nuclei of the neuroglial cells are not placed alongside one another, as we find in the larva, but are very far apart from one another.

The course of development of the central body in Gryllus domesticus L. was very similar to that in the bee. The only difference lay in the fact that the whole process of development of the central body took place in the egg in this case. At a certain stage of development the brain of the embryo cricket has still a very simple structure (Fig. 8). Neuropile occupies its smaller part and consists of loosely placed tracts of fibers extending in all directions. There are no mushroom bodies, no central bodies and no protocerebral bridge. Yet even at this period we can see some of the nerve strands peculiar to the brain of the imago. Especially prominent among them is the olfactory strand and the deutocerebral commissure. Above the latter there is another large commissural bundle, formed by fibers of cells lying in the pars intercerebralis and between the main and accessory lobes of the protocerebrum. In these groups of cells, as also in other parts of the brain, we still find solitary neuroblasts (Fig. 8, snb). Sometimes assymetrical mitoses can be observed in them (dsn). The brain of the cricket at this stage of development is thus very similar to the brain of the two-to-three-day old bee larva.

At the next stage of development the above-mentioned bundle becomes thicker, but its neuropile remains homogeneous. Later there is a further growth of the bundle, and its neuropile divides into a number of glomeruli, which are underlain by a strip of structureless fibrous matter. At this time this strip represents the lower part of the central body (Fig. 9, a).

Gradually both parts enlarge (Fig. 9, b) and in the newborn nymph the central body assumes the full imaginal form (Fig. 9, c). The upper part is subdivided into eight lobes and is very convex on top. The lower part, consisting of homogeneous neuropile, fits into its ventral hollow. We can easily observe the connections of the central body with the cells of the pars intercerebralis, the cells of the accessory protocerebral lobes, and also with the fibrous matter of the rest of the protocerebrum.

Thus, the Homoptera, on the one hand, and the Polyneoptera and Oligoneoptera on the other, differ markedly in the course of development of the central body, although in the insects of all these groups similar assemblages of neurons participate in the formation of the latter. At present it is still impossible to determine why the lower part is initially more strongly developed in aphids, while in Polyneoptera and Oligoneoptera the upper part dominates from the very beginning. In any case, the rapid development of the upper part cannot always be associated with the initial differentiation of the compound eyes, as was done by Pflugfelder [1936] since in many larvae of the Oligoneoptera, which in the majority of cases, as we know, possess only stemata, the central body is represented by its upper part. The lower part begins to develop only in the prepupa —a state of affairs rather the reverse of that observed by Pflugfelder.

On the other hand, we can apparently surmise that the course of development of the central body in Polyneoptera and Oligoneoptera is more primitive, since in some primitive forms (Japygidae [Hanstrom, 1928, 1940]) the central body of the fully grown individuals consists of one row of large glomeruli, drawn out across the brain. In others (Machilidae) it is also usually drawn out across the brain, but it is not divided into glomeruli.

SUMMARY

This work is devoted to a study of the development of the central body in different representatives of the Polyneoptera, Oligoneoptera and Ephemeroptera.

In the Polyneoptera the central body develops during embryogenesis. During the postembryonic period only growth of the central body takes place.

Newborn larvae of Ephemeridae possess no central body. The latter appears and develops during the larval and nymphal periods.

Among the Oligoneoptera a few newborn larvae have no central body (Musca domestica L., Apis mellifica L., Anthonomus rubi Hbst.). The others (Tenebrio molitor L., Ascalaphus, Chrysopa, Antheraea pernyi Guér.) already possess it at this time. As the larvae of the first group are blind, this supports the view of Bretschneider [1914] that the degree of development of the central body depends on that of the organs of vision and their centers. The larval central body consists only of the upper part, which appears as a row of large glomeruli and resembles the central body of Japyx.

Ir is shown in this work that the course of development of the central body in the Oligoneoptera, Polyneoptera and probably the Heteroptera is similar. The central body initially appears as a commissural tract of fibers, which is composed of the nerve processes of neurons situated in the pars intercerebralis and between the main and accessory lobes of the protocerebrum. A little later there appears the upper part of the central body, which consists of several glomerules extending across the protocerebrum.

The lower part of the central body, the neuropile of which is homogeneous, also gradually develops. The lower part, however, never dominates over the upper part. In this respect the Oligoneoptera and Polyneoptera on the one hand, and the Homoptera on the other, differ, since in the latter [Pflugfelder, 1936-37] the lower part of the central body is larger at first than the upper part. A further difference is that in the Poly- and Oligoneoptera, in contrast to the Homoptera, the growth of the lower part, and not the upper part, of the central body coincides with the initial differentiation of the compound eyes

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RELECTION OF ULTRAVIOLET RAYS BY FLOWERS, AND INSECT VISION

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There is no doubt that the color of the corollas of plants are of signal importance for insects—their pollinators. The variety of colors of flowers together with their diversity of scent and form enable insects to find particular flowers by sight.

After Kühn and Pohl [1921] had established that the honeybee can be trained to ultraviolet rays, i.e., it was possible to condition them to discriminate between ultraviolet rays and the rays of the visible spectrum, it became of interest to study the nature of the reflection of ultraviolet rays by the corollas of plants. The question requiring an answer was: To what extent do these rays help insects to identify flowering plants?

Richtmyer [1923] was the first to publish results of measurements (by means of quartz spectrograph) of the ultraviolet reflection coefficients of petals of a series of plants of the North American flora. He found that out of 25 plants taken only the corollas of four reflected more than 10% of the ultraviolet light, these being Onagra biennis, Rudbeckia laciniata, Lacinaria punctata and Solanum rostratum. Moreover, all the plants which he investigated differed considerably in the degree to which they reflected those rays. Yet the answer to the question posed by Richtmyer: "Is the amount of ultraviolet reflected by flowers sufficient to play an important role in the plant coloration perceived by insects?", the author left to biologists.

This question was dealt with in the work of Lutz [1924], who photographed flowers in ultraviolet light and made a qualitative study of the nature of ultraviolet reflection in several North American plants. He found that only 30% of all the investigated flowers reflected ultraviolet reasonably strongly and that they usually had a yellow, red or blue coloration. In white flowers strong reflection of ultraviolet occurred very rarely. As a result of his studies Lutz concluded that the role of ultraviolet reflected by flowers in the visual perception of insects was a minor one, since plants with a high ultraviolet reflection rarely occur in nature. Crane [1954] later subscribed to the same conclusion.

A determination of the ultraviolet reflection coefficients (for λ — 313 and 365 m μ) of flowers of European plants was carried out by Lotmar [1933]. According to his results, about one quarter of the 80 species examined reflected ultraviolet in appreciable amounts, i.e., more than 4-5% for λ = 365 m μ. This fact (in effect, the same as that established by Lutz [1924]) and his success in training bees to discriminate ultraviolet light reflected by petals (the petals were covered with special filter to absorb all the other rays), led Lotmar to suggest the great importance of ultraviolet in flower recognition by insects. Weiss expressed practically the same view in his review of works on the color vision of insects.

Among other studies bearing on the subject under discussion the results of Popp and Brown [1936] and Kalitin [1941] are known to us. Popp and Brown found that leaves of 10 plants studied by them reflected up to 9% of radiation with λ = 336 m μ. According to Kalitin [1941], the albedo of summer (green) leaves of trees for the whole visible spectrum (400-720 m μ) varies from 9 (raspberry) to 21% (silverberry); the absorption by leaves of light of different portions of the spectrum was higher, the shorter the wavelength.

The aim of the present article is a critical assessment of the contradictory opinions of different authors on the role of ultraviolet in flower recognition by insects. It is based on measurements, made in 1955 and 1956, of the degree of ultraviolet reflection by flowers and green parts of plants of the central Russian, mainly wild, flora.

TABLE 1

Intensity of Ultraviolet Reflection by the Corollas of Flowers of Different Color

Color of corolla	No. of plants invest.	Intensity of ultraviolet reflection					
		about 1%	up to 5%	from 5 to 10%	from 10 to 20%	from 20 to 40%	40% or more
White	16	2	12	1	1	0	0
Red	3	0	0	2	0	1	0
Orange	4	3	0	0	1	0	0
Yellow	14	1	2	1	4	5	1
Pink	9	2	3	1	2	0	1
Blue	10	0	4	3	2	1	0
Lilac	9	1	2	3	2	1	0
Purple	12	2	5	3	0	0	2
Totals	77	11	28	14	12	8	4

METHODS

The method used in this investigation did not differ essentially from the experimental technique which we employed earlier to determine the ultraviolet reflection coefficients of the wings of Lepidoptera [Mazokhin, 1957].

The plants and a scale of standards of known reflection coefficients were photographed simultaneously (linear scale 1:3) in sunlight. The light was made monochromatic by using an ordinary glass lens carrying a light filter VG-1, and desensitized film, and as result we were able to take photographs in ultraviolet light with an energy maximum in the region of 360 m μ. The reflection coefficients were evaluated by comparing (by means of a

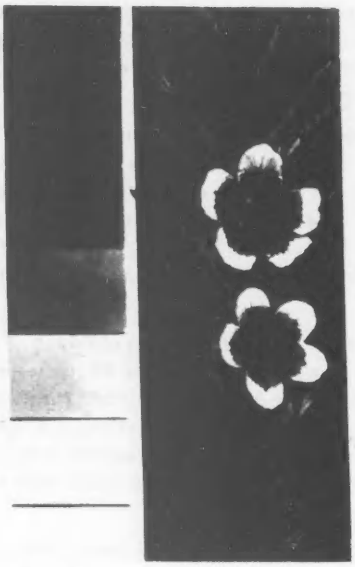

Fig. 1. Photograph (positive) of flowers and leaves of silverweed (Potentilla anserina) in ultraviolet light. At left in all figures: scale of standards with reflection coefficients from 3.5 to 70%.

Fig. 2. Photograph (positive) of flower and leaves of dandelion (Taraxacum officinale).

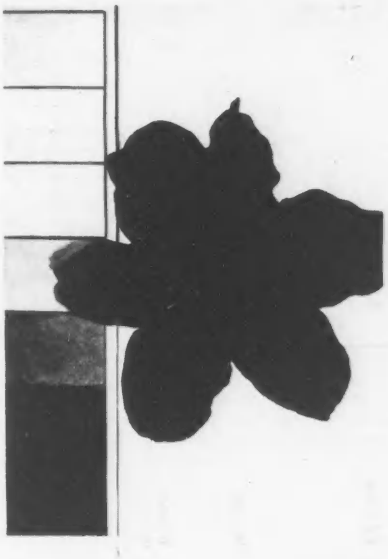

Fig. 3. Photograph (positive) of flower of white narcissus (Narcissus poeticus) in ultraviolet light.

Fig. 4. Photograph (positive) of flowers and leaves of lungwort (Pulmonaria angustifolia) in ultraviolet light.

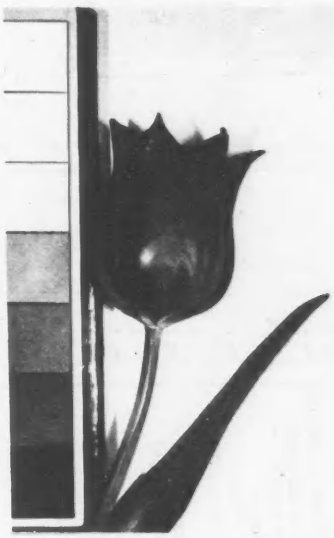

Fig. 5. Photograph (positive) of flower and leaves of Schrenk's tulip (Tulipa schrenkii) in ultraviolet light.

Fig. 6. Photograph (positive) of flowers and leaves of Geranium sp. in ultraviolet light.

TABLE 2

Ultraviolet Reflection Coefficients (in %) (λ = 360 m μ) of Flowers and Green Parts of Plants

Name of plant	Flower (inside)						Leaf	Stem	Notes
	corolla		base of corolla		reproductive organs				
	%	color	%	color	%	color			
1. Narcissus (N. poeticus)	≈ 2.5	White			< 1	Yellow			
2. Butterfly orchis (Platanthera bifolia)	3	»						4	
	3	»					5		
3. Bindweed (Convolvulus arvensis)	3.5	»					3.5	3.5	Outer surface of corolla reflects 13%
4. White campion (Meladrium album)	2.5	»					3.5	3.5	
5. Milfoil (Achillea millefolium)	≈ 2	»			≈ 2	Yellow		3.5	
6. Ox-eye daisy (Leucanthemum vulgare)	≈ 2	»					5		
7. Hoary plaintain (Plantago media)	3.5	»					5		
8. Tobacco (Nicotiana sanderae)	5—8	»					3.5		
9. Melilot (Melilotus albus)	≈ 1	»					3.5		
10. Phlox sp., white form	16	»			> 1	White		4	
11 Cornflower Centaurea cyanus, white form)	≈ 2	»					3		
12. Elder (Sambucus racemosa)	≈ 1	»					4		
13. Strawberry (Fragaria vesca)	3	»					3		
14. Pear (Pyrus communis)	≈ 2	»			≥ 1	White	4		
15. Cinquefoil (Potentilla alba)	≈ 2	»			≥ 1	White			
16. Anemone (Anemone sylvestris)									

TABLE 2 (continued)

Name of plant	Flower (inside)						Leaf	Stem	Notes
	corolla		base of corolla		reproductive organs				
	%	color	%	color	%	color			
17. Tulip (Tulipa schrenkii)	6	Red	12	Yellow			5	9	Figures refer to outer surface of corolla
18. Scarlet (Lychnis chalcedonica)	6	»					3		
19. Poppy (Papaver rhoeas)	21	»	6	Black					
20. Cow-wheat (Melampyrum nemorosum)	≈1.5	Orange					3		Bracts (lilac) reflect 5%
21. Dyer's greenweed (Genista (tinctoria)	15	»					3		
22. Tansy (Tanacetum vulgare)	≈1	»					3.5		
23. Garden nasturtium (Tropaeolum sp.)	>1	»	5	Yellow			4		Outer orange part of petals reflect 5%, yellow 27%
24. Dandelion (Taraxacum officinale)	20	Yellow			3	Yellow	3	3	
25. Yellow bedstraw (Galium verum)	2	»					3	3	
26. Hawkbit (Leontodon autumnalis)	30	»	3	Yellow			3.5	3.5	
27. Wild radish (Raphanus raphanistrum	25	»					4		
28. St. John's wort (Hypericum quadrangulum)	15	»			3	Yellow	3.5		

TABLE 2 (continued)

Name of plant	Flower (inside)						Leaf	Stem	Notes
	corolla		base of corolla		reproductive organs				
	%	color	%	color	%	color			
29. Melilot (Melilotus officinalis)	16	Yellow					4	4	
30. Yellow toadflax (Linaria vulgaris)	≈ 1.5	»					6		
31. Bird's-foot trefoil (Lotus cormculatus)	3	»					4	4	Figures refer to outer surface of corolla.
32. Silverweed (Potentilla anserina)	20	»	≈ 2	Yellow			3.5		
33. Sunflower (Helianthus annuus)	10	»	> 1	»			4		
34. Goat's beard (Tragopogon pratensis)	10	»			≈ 1	Yellow			
35. Pheasant's eye (Adonis vernalis)	45	»			≈ 1	»	2		
36. Yellow rocket (Barbarea vulgaris)	35	»							
37. Buttercup Ranunculus sp.)	6	»			> 1	Yellow			
38. Cuckoo flower (Coronaria flos cuculi)	40	Pink	3	Pink				< 1	
39. Catchfly (Viscaria viscosa)	10	»						≈ 1	
40. Maiden pink (Dianthus deltoides)	≈ 1	»					3.5	3.5	
41. Spiraea sp.	≈ 1.5	»					4		
42. Willow-herb (Chamaenerium angustifolium)	3	»					3.5		
43. Dog-rose (Rosa canina)	15	»	≈ 1	Pink	≈ 1	Yellow	3		
44. Knotweed (Polygonum scabrum)	6	»					3		
45. Apple (Malus pumila)	4	»			> 1	White	4		
46. Milkwort (Polygala comosa)	3	»							
47. Bluebell (Scilla sibirica)	3	Blue					4		

TABLE 2 (continued)

Name of plant	Flower (inside)						Leaf	Stem	Notes
	corolla		base of corolla		reproductive organs				
	%	color	%	color	%	color			
48. Dragonhead (Dracocephalum ruyschiana)	7	Blue					3.5		
49. Jacob's ladder (Polemonium caeruleum)	8.5	»	≈ 2	Blue			6		
50. Cornflower (Centaura cyanus, white form)	21	»			> 1	Pale blue		4	
51. Lupin (Lupinus sp.)	10	»					3.5		
52. Iris (Iris aphylla)	6	»					6		
53. Bugleweed (Ajuga genevensis)	13	»					3		
54. Sage (Salvia pratensis)	3	»							
55. Forget-me-not (Myosotis sylvatica)	≈ 2	»							
	≈ 2	»							
56. Forget-me-not (Myosotis micrantha)	≈ 1	Lilac					3.5		
57. Field scabious (Knautia arvensis)	3.5	»			≈ 2	Yellow	4	4	
58. Woody nightshade (Solanum dulcamara)	6	»							
59. All-heal (Brunella vulgaris)	6	»							
60. Marsh woundwort (Stachys palustris)	9	»					4		
61. Violet (Viola mirabilis)	10	»					3.5		
62. Lilac (Syringa vulgaris)	4	»							
63. Ground ivy (Glechoma hederacea)	30	»							
64. Speedwell (Veronica prostrata)									
65. Potato (Solanum tuberosum)	15	»			3	Yellow	3		
66. Pink (Dianthus borbasii)	≈ 1	Purple						4.5	

TABLE 2 (continued)

Name of plant	Flower (inside)						Leaf	Stem	Notes
	corolla		base of corolla		reproductive organs				
	%	color	%	color	%	color			
67. Geranium sp.	40	Purple	3	Purple	20	Purple	4.5	≈1	
68. Clover (Trifolium pratense)	5	»					3.5	10—12	
69. Knapweed (Centaurea jacea)	≈2	»					3	3	
70. Common vetch (Vicia sativa)	5	»					3.5	3.5	
71. Petunia hybrida	3	»							
72. Stock (Matthiola annua)	3	»							
73. Phlox sp. (purple form)	≈1	»					3.5		
74. Burdock (Arctium tomentosum)	3	»							
75. Thistle (Carduus thoermeri)	3.5	»							
76. Lungwort (Pulmonaria angustifolia)	40	»					3		
77. Vetchling (Lathyrus vernus)	8	»					4		
78. Nonnea pulla	>1	Almost black			4	Reddish	3		
79. Poplar (Populus sp.)							8—10		
80. Box elder (Negundo aceroides)							4		
81. Birch (Betula sp.)									The white bark reflects 40%

photoelectric densitometer) the density of a negative image of the plants and the image of the scale of standards on the same frame.

When the reflection coefficients were determined the specular reflection (highlights) was not taken into account. The accuracy of measurement was about ± 0.5% for the low coefficients and ± 2% for the high.

Measurement of the reflection coefficients by photography enabled us to visualize the complete picture of the ultraviolet reflection of different parts of the plants and to note similarities or differences in their corresponding "ultraviolet coloration".

Measurement of Ultraviolet Reflection of Flowers and Green Parts of Plants

We examined more than 80 species and forms, consisting mainly of wild plants from the Moscow area and certain steppe plants (from Kursk region). It can be seen from Table 1 that the corollas of more then 36% of all the investigated plants reflect up to 5% of the ultraviolet light. Approximately one third of all the plants reflect more than 10% of this light and only the corollas of four (Coronaria flos cuculi, Adonis vernalis, Pulmonaria angustifolia and Geranium sp.) reflect about 40% of the ultraviolet (Figs. 4, 6).

We can see from this table that cases of high ultraviolet reflection are most often observed in plants with yellow, blue and purple corollas, while the cases of greatest absorption are found among white flowers. We refrain, however, from generalizing about the relationship between the visible color of the corolla and the nature of their ultraviolet absorption since any causal relationship is hard to find. Such a relationship must be sought in the general pigmentation and structural nature of the flower integument, and not in their visible color, as was done by Lutz [1924] and Lotmar [1933].

As we may note from Table 2, the investigated plants differ quite considerably in the degree to which they reflect ultraviolet. Moreover, not all parts of the corolla reflect ultraviolet in equal measure; the base of the petals (where the nectar glands are located) almost always reflect less than their subapical parts. The reproductive organs of the flower (pistils and stamens) also usually absorb ultraviolet more strongly than the petals (Figs. 1, 2, 4). As a result of this the corollas of certain plants, for instance silverweed, dandelion, sunflower and hawkbit, despite their uniform yellow coloration, show marked color contrasts in the ultraviolet photographs: on the periphery of the inside surface of the corolla there is a pale rim reflecting ultraviolet about 10 times more strongly than its base.

The fact that Lotmar [1933] was apparently unaware of this uneven absorption of the rays by different parts of the petal explains the discrepancies in the value of the ultraviolet reflection in his and our results for certain plants (sunflower, dandelion etc.).

The corollas of plants of the same species, despite a certain variation in color, which is probably related to different phases of flowering, growing conditions and other factors, are nevertheless characterized by fairly constant reflection coefficients: the variation in their absolute values in separate individuals rarely exceeds 3-5%. It is worth noting also that in flowers of some species of plants, despite a marked difference in coloration, the ultraviolet reflection coefficient remains almost constant, for instance: the blue form of cornflower (Centaurea cyanus) reflects 21% of the ultraviolet, while its entirely white form reflects 16%; the purple form of phlox reflects 1% of the ultraviolet and its white form the same amount. On the other hand, in a fair number of the flowers the outer and inner surfaces of the petals have different reflection coefficients in the ultraviolet, although to the eye their color is very similar (Table 2).

The leaves of herbaceous plants, despite the fairly strong color differences in various species, have very similar ultraviolet reflection coefficients, lying in the range 2-6%. Their stems reflect 1 to 12% of the ultraviolet light. Leaves of woody plants appear to reflect ultraviolet more strongly, for instance poplar—8-10%. The white bark of birch reflects about 40% of this radiation.

Importance of Ultraviolet Light for Insects in the Recognition of Flowering Plants

Before assessing the importance of ultraviolet light for insects in the recognition of plants, we must recall what, in general, determines the color of any object.

Almost all the objects with which we have to deal do not give off light themselves, but merely reflect light incident on them from outside. Hence differences in color of objects are due to the fact that the light

incident on them is partially absorbed and reaches the observer's eye in an altered form. The different colors of objects is a result of their absorption of light. An object of a particular color possess a particular absorption band, which is independent of the spectral composition of the incident light. Depending on the width of the absorption band or the number of bands, the color of objects may be simple as regards spectral composition, when the object absorbs almost all the rays of the spectrum except some narrow region, or complex, when the object has narrow absorption bands. For instance, certain red objects absorb all the rays except the red, yellow objects have a narrower absorption band in the blue-violet part of the spectrum and strongly reflect green, yellow, orange and red rays. Green objects absorb, on the one hand, red rays and, on the other, dark blue and violet.

For man, whose eye is sensitive to rays from violet to red inclusive, all the diversity of colors of objects is produced by the selective absorption of rays only within this spectral interval. For insects the visible spectrum is wider: it includes a portion of the ultraviolet from 300 m μ. In correspondence with this the color of objects to the insect's eye will be determined by the nature of the absorption of all the rays visible to it, including the ultraviolet rays. For them a white object with an absorption band in the ultraviolet will differ in color from another white object which reflects the ultraviolet. The same thing holds for objects of any other color with different ultraviolet absorption. In short, since the insect eye is sensitive to ultraviolet rays, these rays will participate in the visual perception of insects just like any other rays visible to them. This is one of the set of questions under examination, and its correct interpretation was given by Hertz [1937, 1938] as early as 1937.

Yet almost all the investigators who have devoted themselves to a study of the role of ultraviolet light in the identification of objects by insects [Lutz, 1924; Lotmar, 1933; Weiss, 1943; Crane, 1954] did not, in our opinion, formulate clearly the problems to be solved, and thus were led to confused or erroneous conclusions. They did not distinguish between three different questions: 1) How do ultraviolet rays participate in the color perception of insects? 2) How do they help in the recognition of objects? and 3) Does the sensitivity of the insect eye to these rays have special adaptative significance? For instance, Crane [1954] writes: "All this (referring to the weak ultraviolet reflection of flowers and the insect integument, and also to the "absence" in different species of distinctive features visible only in ultraviolet rays, —G. M.-P.) is in accordance with the conclusion of other authors [Lutz, 1914; Weiss, 1945, 1946] on the apparent lack of correlation between the sensitivity of insects to ultraviolet and the amount of ultraviolet either in their environment, in general, or reflected by the flowers which they pollinate."

We will attempt to examine these questions separately.

The first one has already been analyzed above and, in our view, in sufficient detail.

The second question is inseparably linked with the physiological meaning of the concept "to see" some object. To see an object means to distinguish it from its surroundings (background). The object is easy to see when it reflects little light, but not so when it reflects light in the same way as its background [Mazokhin, 1956, 1957]. Hence, for flowers to be distinguished in ultraviolet it is not at all essential that they should reflect ultraviolet strongly (and this is what was required by the concepts of Lutz and the other authors), but it is essential that they reflect these rays in a different way from the background i.e., to a greater or lesser degree than the background. It is not the degree of reflection of the light which is important, but the degree of difference in the reflection by the object and background. The usual background of a flower consists of the leaves and stems, and there are almost always differences in the ultraviolet absorption of the former and the latter. In the case where the ultraviolet reflection of leaves and flowers is similar, the perception of the latter will depend on the differences in their absorption of other rays of the spectrum. Hence we can assert that ultraviolet rays do assist insects to distinguish one flower from another, as well as from leaves. This is illustrated by the figures in Table 2, where we can see different degrees of absorption of ultraviolet between different flowers and between flowers and leaves. The latter case is most important for insects with a low sensitivity to red rays (bees), for which the distinguishing of yellow or orange corollas on a green background only by their degree of reflection of the long wavelengths would be very difficult.

Examples to show that ultraviolet rays, as well as rays of other parts of the spectrum, actually help insects, bees for instance, to find particular objects, can be found in the works of Englander [1941], and Braines and Istomina [1956]. For instance, according to Englander, bees can easily discriminate between various kinds of whitewash, which have different ultraviolet absorption. This could perhaps be put to use in the painting of hives, so that the bees could find their own colonies more easily. According to Braines and Istomina, screens with a high ultraviolet reflection, laid on the ground, were the most effective guides for directing the flight of bees to particular collecting areas.

Hence, the view logically developed here is similar to that of Lotmar [1933] in regard to the importance of ultraviolet light for insects, though this author had quite a different basis for his opinion. Lotmar believes that ultraviolet plays a role in the recognition of flowers by insects because a quarter of all the flowers reflected it strongly enough. This view was very prominent in the discussion of Lotmar [1933] and Frisch [1955], which we critically examined earlier [Mazokhin, 1956], on the importance of the high ultraviolet reflection of the red poppy (Papaver rhoeas) for the visual perceptiveness of bees.

Lastly, the third question: Does the sensitivity of the eye to ultraviolet light have a special adaptative significance for the insects, i.e., did the sensitivity of the eye to ultraviolet originate as some special adaptation? Lutz [1924], Crane [1954] and other authors answer this with a negative, together with the whole question of the participation of ultraviolet in the visual perceptiveness of insects. In support of this conclusion they put forward the argument of the weak ultraviolet reflection of flowers and the alleged absence in plants and animals of specific markings visible only in these rays. However, as we have shown in this and previous work [Mazokhin, 1954, 1957], there are such markings, hidden from the human eye, both in insects and flowers. Such are the humanly invisible markings on the wings of lepidopterans, and in the plant kingdom, the specific ultraviolet coloration of silverweed (Fig. 1), campion, dandelion etc. However, it seems to us impossible at the present time, owing to the lack of other factual data, to prove or refute the above-mentioned hypothesis of Lutz [1924] and other authors.

SUMMARY

A photographic method was used to determine the reflection coefficients in the near ultraviolet (with maximum in region of 360 m μ) of the corollas and green parts of more than 80 species of central Russian plants.

The corollas of approximately 1/3 of all the plants studied reflected up to 5% of the ultraviolet light, in another third they reflected more than 10% of these rays, and in 4 species we noted a reflection of about 40% of the ultraviolet by the corollas (Adonis vernalis, Coronaria flos cuculi, Pulmonaria angustifolia and Geranium sp.).

The base of the petals usually absorbs ultraviolet more strongly than their periphery. The reproductive organs of the flower also absorb ultraviolet much more strongly than the periphery. In this connection the apparently uniformly colored corollas of certain plants (unicolorous yellow Potentilla anserina, Adonis vernalis, Taraxacum officinale) have "hidden" markings, visible only in ultraviolet light. Such markings are undoubtedly perceived by insects.

The leaves of herbaceous plants, as compared with their flowers, reflect ultraviolet rays much less strongly and more uniformly, in the range 2-6%.

Ultraviolet rays participate in the visual perceptiveness of insects and help them to distinguish flowers and other objects to the same extent as the other rays visible to them. The discernment of a flower is determined not by the intensity of reflection of any rays, but by the difference in reflection of the flower and the background against which it lies. Hence the low average reflection of ultraviolet by flowers still does not rule out the importance of these rays for insects in the recognition of flowering plants, since the leaves and the stems (background) reflect ultraviolet to a different extent and much more uniformly than the corollas.

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THE EFFECT OF SHELTERBELTS, IRRIGATION AND PERENNIAL GRASSES ON THE NUMBERS OF FRIT AND HESSIAN FLIES

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Effect of Shelterbelts

The role of shelterbelts in reducing the force of the wind and the summer air and soil temperature, as well as in increasing the absolute and relative humidity of the air, is generally known.

Vinokurova [Vinokurova and Burnatskii, 1951] has indicated the immense importance of shelterbelts in increasing the snow cover, thus leading to an improvement in the soil moisture conditions; the wind-shielding action of shelterbelts in periods of drought reduces the loss of water by soil and crops. Under the influence of shelterbelts the microclimate of the sheltered areas acquires features of a mesophilous nature and may promote the multiplication of certain mesopholous insect pests [Mel'nichenko, 1949], particularly on fields situated close to the shelterbelts, at distances 50-100 m from them. According to investigations in the Kamennaya Steppe [Vinokurova, 1951], the air temperature on hot summer days on the open steppe was 0.3 to 1.6° higher than among the shelterbelts; sometimes this difference reached 2.3°; the relative humidity at the height of the winter wheat cover among the shelterbelts was increased by 3-10%. The force of the wind in a field among the shelterbelts at a distance of 10 m from the tree belt was reduced by 69-100%, at a distance of 50 m by 32-87%, and at a distance of 100 m by 17-77%.

It is important to know how the numbers of hessian and frit flies–the principal pests of grain crops–are affected by shelterbelts.

The literature contains very little information on the effect of shelterbelts on the numbers of hessian and frit flies.

On the fields of the Timashevo shelterbelt area in 1935, 1937 and 1938 Mel'nichenko [1949] observed the destruction of plants by cereal flies, which attained, in his words, impressive proportions, while outside the shelterbelts the percentage loss of plants due to their activity was barely perceptible even in years of the greatest multiplication of the flies. According to the results of a year's investigation by Selivanova and Zhukovskii [1952], the hessian fly is several times more numerous among the shelterbelts than on the steppe, while the frit fly attacks plants on the steppe and among the shelterbelts to an equal degree. Titov [1937] found that in 1935 winter wheat was 7-8 times more heavily infested with hessian fly on the steppe than on fields among the shelterbelts; for frit fly he indicated that the average damage to stems of spring wheat in the Kamennaya Steppe in 1935 was 1.5% of all stems on the steppe, and 3.2% among the shelterbelts while the average damage to winter wheat, according to the spring analyses, was 2.04% on the steppe, and 8.4% in the shelterbelts.

The hessian fly (Mayetiola destructor Say). The effect of shelterbelts on the number of hessian flies was studied in 1950-1954 in the V. V. Dokuchaev Institute of Agriculture (Central Black-Earth Zone). Comparative surveys were made on fields under a seven-field rotation on the steppe and in fields among shelterbelts with the same seven-field rotation as on the steppe, and with the same alternation of crops in both rotations. The size of each field in the seven-field crop rotation among shelterbelts varied between 25 and 29 ha; the width of the shelterbelts bordering these fields varied from 106 m (on the east side) to 20-40 m on the other three sides; at the boundaries between the tree belts (at the corners of the fields) there were treeless areas, varying in width

from 30-50 m. The shelterbelts were to open structure, the height of the trees 18-22 m, and their composition was varied. The distance between the fields situated on the steppe and the fields bordered by tree belts was 2.5km.

Our observations showed that the importance of the shelterbelts for the multiplication of hessian fly varied with the different crops. Hence we will make a comparison of the numbers of this insect for each crop separately.

Winter wheat. The trees in the shelterbelts did not form a solid barrier, but in foliage they constituted a considerable obstacle to migrating flies on the wing. At the end of August and in September the hessian fly migrates from the fields where the wheat has been harvested to fields containing shoots of winter wheat. At this time there usually appears a great network of spider webs among the branches of the trees, and this network blocks the flight of the insects. The flies are caught in the webs and stick there. Some flies, when they come up against the shelterbelt barrier, cease their flight and start to crawl, and then they are killed by predatory insects and spiders. According to the investigations of Matkovskii [1939], the hessian fly cannot rise more than 3 m above ground.

In 1951-1954 we studied the distribution of flies on fields occupied by winter wheat and surrounded by 50-to 60-year-old shelterbelts. Onfallow fields brought under fallow after oats and kept free from weeds during spring and summer, the hessian fly was not found either in the adult stage, or in the egg, larval or pupal stages. We also conducted investigations on winter wheat sown on such fallows. We compared the infestation of winter wheat on fields among shelterbelts with fields on the steppe, where the same order of alternation of crops had taken place and the same agricultural measures had been employed over several years.

TABLE 1

Numbers of Hessian Fly Larvae of the Autumn Brood (Winter Stock) on Winter Wheat on the Steppe and among Shelterbelts

	Location of crops	No. of stems examined	No. of larvae on stems	Mean No.of larvae per 100 stems
1951	On the steppe	2860	380	13.3 ± 1.10
	Among shelterbelts	1625	81	4.9 ± 0.44
1952	On the steppe	2603	68	2.7 ± 0.25
	Among shelterbelts	1995	32	1.6 ± 0.28
1953	On the steppe	312	200	6.04 ± 0.81
	Among shelterbelts	5305	83	1.58 ± 0.37
1954	On the steppe	2757	268	9.70 ± 0.72
	Among shelterbelts	2492	162	6.50 ± 0.80
Average of 4 years	On the steppe	—	—	7.9
	Among shelterbelts	—	—	3.6

The numbers of fly larvae on shoots of winter wheat on the open steppe and in fields surrounded by 50-to 60-year-old shelterbelts were determined by taking 5-6 replicate samples of plants, analyzing them and subjecting the figures to mathematical treatment.

The numbers of larvae are given in Table 1.

It can be seen from this table that on fields surrounded by shelterbelts, the shoots of winter wheat were attacked in autumn by the hessian fly but the degree of infestation was more than halved. Hence, shelterbelts prevent the flies invading the sheltered fields. The tree belts would constitute a greater barrier to the spread of the hessian fly and other insects if there were no 30-50 m intervals at the corners of the fields, as there are in the Dokuchaev shelterbelts, thus facilitating the passage of insects from one field to the other.

In spring the winter wheat is attacked by hessian fly from the overwintered false-coooons and larvae. On fields of winter wheat on the open steppe the winter stock of larvae was much greater than among the shelterbelts,

TABLE 2

Numbers of Hessian Fly Larvae of Spring Brood

	Among shelterbelts			On steppe		
	stems examined	stems attacked (in %)	No. of larvae per 1 m^2	stems examined	stems attacked (in %)	No. of larvae per 1 m^2
1950	645	2.2	33	590	1.5	23
1951	480	11.4	171	510	8.2	120
1952	730	25.2	378	820	21.1	315
1953	570	14.6	219	659	10.7	155
1954	1087	9.6	150	960	13.1	195
Mean	—	12.6	190.2	—	10.9	161.6

as can be seen from Table 1. Hence on the steppe in spring we should expect a heavier infestation of the winter wheat. In fact, this is not generally the case. On the contrary, in spring the hessian fly leaves more progeny on the winter wheat in the shelterbelts than on the steppe (Table 2).

This is due to the fact that shelterbelts moderate the high spring-summer temperatures and reduce the lethal action of dry winds on the hatching larvae, i.e., they create more cogenial conditions for the survival of the progeny of the flies. Selivanova and Zhukovskii [1952] point out that shelterbelts in steppe regions can promote a higher survival of the pest and the formation of local centers of infestation.

It can be seen from Table 2 that during the four years (1950-53) the spring brood of larvae on the steppe was smaller than among the shelterbelts, and only in 1954 was it a little higher, since the wintering stock of larvae in winter 1953/54 on the steppe was almost 4 times that on winter wheat among the shelterbelts.

Thus, at the end of summer and in autumn the tree planting, being in foliage, to a large extent prevent the migration of hessian fly on to winter wheat sowings surrounded by shelterbelts. The system of shelterbelts would have been more effective in preventing the invasion of flies, if it had been continuous, i.e., if there had been no large clearings at the corners of the fields. In this case the infestation of winter crops in autumn in the shelterbelts would have been reduced even more and it would also have reduced the damage done by the spring brood of the hessian fly.

TABLE 3

Infestation of Spring Wheat Lyutestsens 62 by Spring Brood of Hessian Fly (number of larvae per 100 stems)

	Among shelterbelts			On steppe		
	No. of stems in analysis	stems attacked (in %)	mean No. of larvae per 1 m^2	No. of stems in analysis	stems attacked (in %)	mean No. of larvae per 1 m^2
1950	678	2.0	9	1167	1.0	4
1951	1078	17.8	85	940	7.3	32
1952	853	61.2	325	974	53.2	265
1953	891	27.1	135	682	9.0	40
1954	674	19.5	95	485	19.2	84
Mean	—	25.5	129	—	17.9	85

TABLE 4

Comparative Infestation of Agropyrum tenerum by Hessian Fly on Steppe and among Shelterbelts

	Among shelterbelts		On steppe			Among shelterbelts		On steppe	
	stems attacked (in %)	No. of larvae per 1 m²	stems attacked (in %)	No. of larvae per 1 m²		stems attacked (in %)	No. of larvae per 1 m²	stems attacked (in %)	No. of larvae per 1 m²
	Apring brood of hessian fly					Autumn brood of hessian fly			
1950	0.9	18	0.1	12	1950	3.1	48	23	46
1951	4.4	88	4.0	80	1951	20.5	410	14.2	275
1952	26.0	520	20.5	410	1952	22.8	356	19.2	346
1953	5.0	100	2.8	56	1953	0.9	18	0.4	8
1954	2.2	44	1.1	22	1954	2.1	42	1.7	35
Mean	7.7	154	5.8	116	Mean	9.9	175	7.6	142

Spring wheat. Among the shelterbelts and on the steppe the spring wheat was preceded by a sward of perennial grasses or an overturned sward. We compared the numbers of larvae on wheat sowings which had been preceded by the same crops.

The plant samples for analysis were taken at the beginning of stalk-formation, when the number of larvae (Table 3) can be most accurately estimated.

The numbers of larvae on spring wheat among shelterbelts in 1950, 1951 and 1953 were very much higher than on the steppe sowings: on fields bordered by shelterbelts they were 2-to 3-times more numerous.

In 1952 and 1954 the infestation of spring wheat on the steppe was only a little less. During the egg-laying period of the flies and the development of the larvae in these years the precipitation was higher than normal, the plants did not suffer from drought, and the humidity of the air was sufficient. Hence there was no great mortality of the fly and its larvae in steppe conditions.

As a result of observations over 5 years it was found that the mean numbers of hessian fly on spring wheat in sheltered fields were not much greater than in the fields on the steppe.

While the autumn brood of hessian fly was more numerous on shoots of winter sowings on the steppe than among the shelterbelts, the spring brood of flies, on the other hand, was characterized by its greater numbers on spring wheat sowings among the shelterbelts. This phenomenon can be attributed to two causes: first, the hessian fly begins to leave its wintering sites early, before the trees in the shelterbelts are covered with foliage and constitute a real obstacle to the flies migrating on to the spring wheat shoots; secondly, spring wheat is not sown on fallow, where the hessian fly is absent from the soil, but after winter wheat, rye and perennial grasses, which leave behind them a considerable stock of wintering hessian fly.

Agropyrum tenerum. The srping brood of the hessian fly on the grass Agropyrum tenerum was more numerous in conditions of tree shelter. This can be explained by the fact that on perennial grasses (as distinct from winter wheat sown on follow) there is always a stock of fly puparia, from which at the end of summer and in autumn there emerge flies which infest the grasses, in this case Agropyrum tenerum (Table 4). The plants of this grass in the second and third year are not attacked by flies which migrate from other sites (centers), but by flies emerging from puparia in the same field.

Frit fly. (Oscinella pusilla Mg.). The degree of infestation and the damage caused by frit flies on fields among old shelterbelts and on steppe were surveyed over a period of 8 years (1948-1955). The observations were made on fields under food-crop rotation among old shelterbelts and on the steppe. Some observations were made on fields under forage-crop rotation on the steppe and under the same rotation among shelterbelts (Table 5).

TABLE 5

Numbers of Frit Fly Larvae on Sowings among Shelterbelts and on Steppe

	Infestation of spring wheat stems by spring brood (in %)		Infextation of rye stems by autumn brood	
	on steppe	among shelter-belts	on steppe	among shelter-belts
1948	6.4	20.5	2.8	1.9
1949	1.0	7.6	2.3	12.8
1950	2.1	4.5	42.0	35.1
1951	10.0	6.6	10.1	6.7
1952	14.3	18.0	4.5	4.8
1953	0.3	1.4	7.5	6.9
1954	0.7	5.2	0.4	0.8
1955	1.8	3.2	5.5	5.0
Mean	4.6	8.4	9.4	9.2

The frit fly infests srping wheat more heavily in shelterbelts than on the steppe; in 1948, 1949, and 1950 this difference was particularly high, while in 1952 and 1953 it was very slight. In 1951, on the other hand, the spring wheat on the steppe was more heavily attacked. This was the only year when the above-noted pattern of infestation of spring cereals on steppe and among shelter belts was altered: in 1951 grain beetles caused heavy damage to spring wheat on the steppe, whereas they were almost completely absent among the shelterbelts. On the injured plants frit flies congregated in large numbers, feeding on the sap exuded at the sites of damage to the tissues. Usually, however, the shelterbelts create rather better conditions for the development of frit fly.

The numbers of frit flies in autumn on winter rye in the sheltered fields were approximately the same as on the steppe. There was practically no difference between the degree of infestation of winter rye by larvae in autumn 1950, 1951 and 1952 on sowings in the sheltered areas and on the steppe. Only in 1949, when the very dry autumn resulted in the flies laying their eggs mainly on the winter cereals among the shelterbelts, were the numbers of larvae on the steppe sowings considerably smaller.

Effect of Irrigation

The literature contains practically no information on the effect of irrigation on the multiplication of hessian fly, apart from the work of Selivanova and Zhukovskii [1952]. According to the data of these authors, there were several times more hessian fly puparia found during one year on the irrigated area than on the steppe or among the shelterbelts. These authors concluded that irrigation in steppe regions could promote the highest survival of the pest and the formation of local infestation centers.

Kuchumov and Zral'ko [1953], who in 1951 studied questions relating to the obtention of high wheat yields on irrigated lands in the region of the South Ukrainian Canal, recorded that on irrigated crops the numbers of hessian flies were very much less than on the unirrigated, whereas on irrigated land the injurious activity of frit fly was increased.

TABLE 6

Comparative Numbers of Hessian Fly Larvae on Irrigated and Unirrigated Spring Wheat.

	Spring wheat variety	Irrigated: stems attacked (in %)	Unirrigated: stems attacked (in %)
1948	Gordeiforme 10	12.1	13.8
1949	Lutestsens 62	3.2	4.3
1950	Gordeiforme 10	0.3	0.5
1951	Lutestsens 62	18.5	9.4
1952	Gordeiforme 10	11.6	9.3
1953	Melyanopus	0.1	0
1954	Narodnaya	3.3	3.0
	Mean	7.0	5.8

TABLE 7

Number of Hessian Fly Larvae on Agropyrum tenerum in Relation to Irrigation

	Irrigated area		Unirrigated area	
	Stems attacked (in %)	Mean number of larvae per 1 m	Stems attacked (in %)	Mean number of larvae per 1 m
1952	34.1	512	35.0	525
1953	2.8	42	1.3	20
1954	6.0	90	0.4	6
Mean	14.3	215	12.2	184

The work in the V. V. Kokuchaev Institute of Agriculture was carried out over several years (1948-1954) on experimental plots in the Melioration Section and on the fields of an experimental farm. From the areas on which the spring wheat was irrigated and from the unirrigated areas we took plant samples at 10 points every 0.5 linear meter in a row at the stage of stalk-formation or at the tillering stage, and then determined the numbers of larvae in the samples (Table 6).

In irrigated conditions the total infestation of the stems by hessian fly was higher, but the infestation of the main stems was approximately the same on the irrigated and unirrigated fields. The irrigated areas provided somewhat better conditions for the multiplication of hessian fly, but the difference in the numbers of the pest on these areas was not great. Spring wheat is usually irrigated first at the tillering stage, 20-30 days after sowing, by which time the flies have succeeded in laying almost all their eggs on the plants, and the larvae which have emerged from the eggs have managed to descend behind the leaf sheath to the base of the stem.

Hence irrigation does not provide better conditions (higher air humidity) for the hatching larvae, when they are exposed on the leaves and are subjected to the drying action of the air. The better conditions of air and soil humidity due to irrigation set in later, when the larvae are found behind the leaf sheath and are comparatively unaffected by the change of soil and air humidity.

Observations on the state of the eggs laid by the hessian fly on leaves during overhead irrigation showed that the eggs of this fly were not washed off the leaves even with relatively high irrigation norms (600 m water per 1 ha).

TABLE 8

Frit Fly Damage to Stems of Spring Wheat (in %) in Late May and June in Relation to Irrigation

	Wheat variety	Irrigated		Unirrigated	
		of all stems	of main stems	of all stems	of main stems
1950	Gordeiforme 10	23.6	5.3	22.3	4.2
	Gordeiforme 10	19.5	5.0	18.1	8.0
1951	Lutestsens 62	15.7	9.0	13.8	7.0
	Vetvistaya * Kakhetinskaya	48.7	19.0	18.3	8.0
	Gordeiforme 10	17.6	6.0	19.3	10.0
1952	Melyanopus 69	19.0	8.0	19.0	4.0
	Vetvistaya Kakhetinskaya	31.3	30.0	18.2	19.0
	Mean	25.1	11.7	18.4	8.6

* Branched.

In 1952 and 1953 the numbers of larvae on irrigated and unirrigated Agropyrum tenerum were determined in June, and in 1954 in October (Table 7).

In 1951 and 1952 (Table 8) there was practically no difference in the frit fly injury sustained by stems of the spring wheats Gordeiforme 10 and Lyutestsens 62 with and without irrigation, but the damage to branched wheat was higher on the irrigated area. This is due to the fact that the first two varieties of wheat after the first watering at the tillering stage usually tiller to approximately the same degree as without irrigation, while the branched wheat as a result of irrigation tillers strongly, forming a great mass of new stems, on which the frit fly readily lays its eggs.

An analysis of stems of the spring wheats Gordeiforme 10 and Melyanopus 69 in June 1952 did not reveal any difference between the damage sustained on the irrigated and unirrigated areas (Table 8), since in May and June of this year the rainfall was heavy (40.2 mm in May, 84.0 mm in June) and there was no significant difference between the moisture conditions on the two areas.

On irrigated sowings the numbers of frit flies began to increase rapidly in July, when the soil on other sowings was beginning to dry up rapidly, the relative soil humidity was greatly reduced and the lateral stems begin to die off entirely. At this time only the irrigated areas retained a considerable stock of pests on the wheat stems (Table 9).

TABLE 9

Frit Fly Infestation of Spring Wheat Stems (in %) in July in Relation to Irrigation

	Wheat variety	Irrigated		Unirrigated	
		of all stems	of main stems	of all stems	of main stems
1951	Gordeiforme 10	47.7	2.5	37.4	2.0
1951	Lutestsens 62	72.0	4.1	40.0	3.0
1951	Vetvistaya Kakhetinskaya	76.0	23.3	51.2	23.0
1952	Melyanopus 69	15.6	4.2	13.6	3.5
1953	Melyanopus 69	16.7	4.0	1.8	0.5
	Mean	45.6	7.6	28.8	6.4

The infestation of all stems was approximately 1½ to 2 times heavier on the irrigated crops than on the irrigated crops than on the unirrigated.

In 1952 the numbers of larvae on the irrigated and unirrigated areas were the same, since in spring and early summer there were frequent showers and the irrigation did not greatly alter the microclimate of the irrigated area. In the dry year 1953 the difference in the numbers of larvae was fairly appreciable, and in the drier 1954 it was even greater: without irrigation the mean number of larvae per 1 m^2 was 6, while with irrigation it was 90. The dense grass cover and the higher air humidity on the irrigated area saved the hessian fly from destruction; here the flies laid several times more eggs: on the irrigated area the average number of eggs per stem in 1954 was 1.2, and on the unirrigated area 0.05.

Importance of Grasses for the Multiplication of the Hessian Fly

The most important wheat pest—the hessian fly—may multiple on certain grasses when wheat plants are not present. In the southern half of the European USSR, where meadows are practically absent in certain regions, the fly can develop on cultivated grasses as well as on the wheat crops. Hence it is desirable to cultivate here those kinds of grasses which are not heavily infested or are not infested at all by this important wheat pest. We must find out which of the many kinds of cultivated grasses do not assist the multiplication of the hessian fly.

Entomologists have more than once found hessian-fly larvae on some species of grasses, but in the majority of cases their numbers on the grasses were not determined. Grigor'eva [1936] records that Znoiko in 1926-1928

TABLE 10

Comparative Numbers of Hessian Fly Larvae on Grasses, Spring Wheat and Barley in Spring (mean number of larvae per 100 stems)

	1950	1951	1952	1953	1954	1955	Mean
Grasses							
Agropyrum tenerum	1.2	2.0	10.8	5.2	2.0	15.7	6.1
A. repens	0.0	0.0	1.1	0.0	1.0	4.0	1.0
A. pectiniforme	0.0	0.5	0.0	0.0	0.0	6.1	1.1
Bromus erectus	0.0	0.0	0.0	0.0	0.0	1.8	0.3
Roegneria fibrosa	—	—	3.8	0.2	0.0	—	1.3
Clinelymus sibiricus	—	—	15.5	5.6	0.2	4.5	6.4
Cereals							
Spring wheat (Triticum vulgare)	0.6	8.5	39.0	12.0	17.5	22.5	16.7
Barley (Hordeum distichum).	0.6	0.5	3.5	0.7	0.4	1.0	1.0

Note: The table gives no data on larval attack on Festuca pratensis, Bromus inermis, Arrhenatherum elatius, Phleum pratense, Poa sp. or Setaria viridis, since no larvae were found on these grasses in spring in the years 1950-1955.

found larvae of this fly on Elymus sabulosus and E. canadensis in the Ukraine. In 1935 Grigor'eva found hessian fly larvae on couch grass (Agropyrum repens) and on two species of feather grass—Stipa rubens and S. lessingiana—in Kazakhstan. Jones [1936, 1938, 1939] records hessian fly infestation of several species of plants belonging to the genera Agrotis, Agropyrum, Aegilops, Elymus, Hordeum, Bromus, Lolium and Phleum; he found a great difference in the extent to which these species were infested by the larvae.

Kryshtal' [1950] relates that hessian fly is found on species of grasses belonging to the genera Agropyrum, Poa, Alopecurus, Beckmannia, Phalaris, Glyceria and Phragmites.

The role of grasses in the multiplication of the hessian fly has received very little study; the literature contains practically no comparative data on the degree of infestation of wild grasses in one locality during one year, far less in the course of several years; there is no information either on the degree of damage to perennial grasses in relation to cropping years, sowing times, the presence of shelterbelts, etc.

Only one species of wild grass—couch grass (Agropyrum repens)—has been investigated reasonably fully in regard to its role as a food plant for hessian fly, but there are different assessments of the importance of couch grass for the multiplication of the pest: Znamenskii [1926] rejected the importance of couch grass for the multiplication of hessian fly while Porchinskii [1882], on the other hand, considered that the hessian fly multiplied to a large extent on couch grass "which constituted the natural primordial cradle of the insect". On the basis of the materials of the Ukrainian Grain Institute, Klokov [1935] gave the degree of damage to cough grass stems as 4-30% in 1931, and 2.5% in 1933. Hence Klokov raised the question of the necessity to destroy couch grass on cultivated land, as well as on the margins of fields and on fallows.

We studied the infestation of perennial grasses and wild grasses during the course of several years on the fields of the Institute of Agriculture and surrounding collective farms, and the comparative numbers of larvae on experimental sowings of the Perennial Grass Section, and in the grass nurseries of this section. For the analyses we took samples of 300-500 stems each from the small plots in the nurseries, and of 800-3000 stems each on the fields of the experimental farm. In Tables 10 and 11 we give the data showing the comparative numbers of hessian fly larvae on grasses in spring and autumn.

TABLE 11

Comparative Numbers of Hessian Fly Larvae (mean per 100 stems) on Grasses in Autumn

	Infestation of stems by autumn-broad larvae (%)						
	1950	1951	1952	1953	1954	1955	Mean
Grasses							
Agropyrum tenerum	2.0	15.5	7.2	4.0	5.9	19.0	8.9
A. repens	0.0	0.0	0.0	0.25	0.0	4.5	0.8
A. pectiniforme	0.3	0.6	0.25	0.0	0.5	3.6	0.8
Clinelymus sibiricus	—	—	1.1	2.0	3.8	3.0	2.5
Roegneria fibrosa	—	—	0.5	0.0	2.1	—	0.7
Bromus inermis	0.08	0.0	0.0	0.0	0.0	0.0	0.01
Cereals							
Winter wheat	3.0	27.0	2.5	8.0	16.5	8.0	10.8
Rye	0.4	1.2	0.4	0.4	0.6	0.5	0.6

Note: The table gives no data on attack on Festuca pratensis, Arrhenatherum elatius, Phleum pratense, Setaria viridis, Festuca sulcata, Dactylis glomerata or Bromus erectus, since no larvae were found on these grasses in 1950-1955.

The spring brood of fly larvae fed on Agropyrum tenerum, on Clinelymus sibiricus, Roegneria fibrosa and to a certain extent on Agropyrum repens.

Of the other grasses, only on Agropyrum pectiniforme in 1951 did we observe fly larvae, but in the other four years we did not find them on this grass. On such grasses as awnless brome (Bromus inermis), upright brome (Bromus erectus), meadow grass (Poa), and bristle-grass (Setaria), hessian fly larvae were not found in any samples over a period of five years. Larvae were not found either on meadow fescue (Festuca pratensis), tall oat-grass (Arrhenatherum elatius), steppe fescue (Festuca sulcata), cocksfoot (Dactylis glomerata) or timothy (Phleum pratense) in analyses over three years.

The grass which stands out from the rest is Agropyrum tenerum, on which the infestation is several times heavier than on the other grasses. The numbers of larvae are also high on Clynelimus sibiricus and Roegneria fibrosa. Agropyrum repens and A. pectiniforme are relatively lightly infested by larvae, much more lightly infested than A. tenerum, although these two grasses belong to the same genus as A. tenerum.

According to Klokov's results [1935], as mentioned earlier, couch grass in the Ukraine is subject to heavy attack by hessian fly; in the southeast Voronezh region we did not observe heavy infestation of this weed even in years when there was a mass outbreak of hessian fly (1951 and 1952). Perhaps this is due to the fact that in the conditions of the Voronezh region, where we carried out our investigations, this weed is sparsely distributed —it grows almost exclusively at the margins of fields, but is very rarely found on the fields—and the hessian fly has become adapted to multiplication on other, commoner species of grass.

On A. repens and A. pectiniforme we found more dead larvae than live ones. Dead larvae were also found on Clinelymus and Roegneria. Puparia from which hessian flies later emerged were found only on A. tenerum, C. sibiricus and A. repens. Hence we can say with certainty that on these grasses the larvae in most cases complete their feeding, and the hessian fly multiplies normally on them.

If we compare the mean numbers of larvae on grasses over 6 years with their numbers on winter and spring cereals, we will see that even on the heavily infested grass—A. tenerum—hessian fly larvae were much fewer than on the spring wheat Lyutestsens 62, and almost equally as numerous as on winter wheat. The larvae were much less numerous on rye and barley than on A. tenerum and C. sibiricus.

The hessian fly was particularly abundant on A. tenerum sown under winter wheat; in 1952,35-100% of its stems were infested (Table 12).

TABLE 12

Numbers of Hessian Fly Larvae on Agropyrum tenerum under Winter Wheat Cover

	Under winter wheat cover		Without cover	
	stems examined	stems attacked (in %)	stems examined	stems attacked (in %)
1950	500	9.9	500	4.3
1952	450	100.0	260	20.2
1953	644	6.5	680	2.9
Mean	-	35.1	-	9.1

In 1950 and 1953 there was a heavier infestation of A. tenerum under winter wheat cover than without cover, when the grass was situated at distances of 200-300 m from the winter wheat. The emerging flies first laid eggs on the grass shoots which were present in the area where the flies emerged and constituted a most convenient substrate for the pest to settle in.

The numbers of hessian fly larvae on A. tenerum and A. pectiniforme during the first year of these grasses depended on the sowing times. In 1950-1952 the populations of hessian fly larvae on these grasses in their first year were studied on summer sowings made at different times on plots of the Perennial Grass Section of the Institute of Agriculture. The grasses were mixed with sainfoin and lucerne and constituted 55-70% of the grass stand. A survey of the infestation of stems by larvae was made in October (Table 13).

The June and July early sowings of A. tenerum were very heavily infested with fly larvae: almost third of all the stems contained larvae of this pest in the 1951 June sowings, and up to 18.3% of the stems in the July sowings, while in the sowings of the second half of August the infestation was only a small fraction of this.

According to Zhukovskii's data [Selivanova and Zhukovskii, 1952] the hessian fly is not found on A. pectiniforme, and hence this grass is not included among the dangerous kinds in which the pest congregates. We also very rarely found larvae on A. pectiniforme of the 2nd-4th year, but on early summer sowings of the 1st year hessian fly larvae were fairly numerous on this grass too. August sowings of A. pectiniforme, as in the case of A. tenerum, were not attacked or were very lightly attacked.

A characteristic feature of the hessian fly infestation of shoots of A. tenerum and A. pectiniforme was the long time that elapsed before the eggs were laid. The fly did not usually begin to lay till 25-30 days after the appearance of the shoots of these grasses. As is generally known, the hessian fly lays eggs on the leaves of wheat, rye and barley on the 2nd-4th day after the appearance of the shoots.

For this reason A. tenerum and A. pectiniforme sown in the second half of August were practically free from hessian fly larvae, while sowings of winter wheat and rye were heavily attacked even when sown in late August, and sometimes even when sown in early September. The larger leaves of the winter cereal shoots attract the flies for egg-laying much earlier than the poorly developed leaves of the grass shoots.

A heavy infestation of A. tenerum by larvae apparently does not lead to a reduced yield of hay and seeds. The grass plants, particularly A. tenerum, have a well-developed root system, tiller vigorously (the mean coefficient of tillering is 8-10), and the loss of stems as a result of damage is speedily made up.

In 1951 and 1952, when 20-38% of the stems of A. tenerum were infested the yield of hay and seed was comparatively high. For instance, in the Institute of Agriculture in 1952 a shelterbelt area crop of A. tenerum, in which 26-38% of the stems were attacked, gave a hay yield of 32 centners per ha from one half of the field, and a seed yield of 3.8 centners per ha from the other half of the field.

TABLE 13

Numbers of Hessian Fly of Summer and Autumn Brood on Summer Grass Sowings in Relation to Sowing Times

Sowing times	Species of grass	Stems attacked (in %)			Mean
		1950	1951	1952	
June	A. tenerum	6.8	27.5	—	17.1
	A. pectiniforme	0.8	3.6	—	2.8
July	A. tenerum	—	18.3	2.2	10.2
	A. pectiniforme	1.0	1.6	0.3	1.0
First half of August	A. tenerum	—	8.3	0.2	4.2
	A. pectiniforme	—	0.8	0.0	0.4
Second half of August	A. tenerum	1.9	0.5	0.0	0.8
	A. pectiniforme	0.0	0.0	0.0	0.0

In 1951, when the 3rd field of A. tenerum among the shelterbelts was infested by hessian fly larvae to the extent of 32.5% of all the stems, the hay yield was 44.8 centners per ha while in the 2nd field on the steppe, where the infestation of stems was 17.8%, the yield was 34.2 centners per ha.

The main danger occasioned by the multiplication of grass flies on perennial grasses is that when they have multiplied on the grasses they migrate on to the wheat sowings, thus causing heavy losses, particularly of spring wheat.

SUMMARY

1. At the end of summer and in autumn the tree plantings, being in foliage, largely check the migration of hessian fly on to the winter wheat sowings surrounded by the tree belts. The system of shelterbelts would have presented a great barrier to the invasion of the flies if it had been continuous, i.e., if there had been no large open areas at the corners of the fields.

2. In contrast to the autumn brood of hessian fly, the numbers of the spring and summer broods of hessian and frit flies are higher on sowings among shelterbelts than on the steppe. This is due to the fact that flies are always present in spring and summer on sowings among shelterbelts, and hence the infestation of the sowings among the shelterbelts was not due so much to flies migrating into them from other fields, but to flies emerging from the puparia which overwintered on the sown areas.

Conditions for the multiplication of the spring and summer broods of the pest are more congenial among shelterbelts than on the steppe, particularly in dry years. In these years the numbers of larvae on the sheltered fields are very much higher, while in years with adequate rainfall they are almost the same as on the steppe.

3. In May and June there is no great difference in the degree of infestation of irrigated and unirrigated sowings by grass fly larvae. The numbers of larvae on the irrigated sowings are higher than on the unirrigated sowings in July, when the summer watering gives rise to new lateral stems, which create congenial conditions both for egg laying and for the survival of the larvae.

4. The hessian fly multiplies in large numbers on such species of perennial grasses as Agropyrum tenerum, Clinelymus sibiricus and Roegneria fibrosa. The fly larvae are less numerous on Agropyrum repens and A. pectiniforme. On the last grass the larvae sometimes occur in large numbers only on the early June and July sowings, while on August sowings the larvae are much less numerous. The hessian fly very heavily infests grasses when they are sown under wheat. Hence it is better to sow these grasses under oats and barley, since the fly does not develop on oats at all, while on barley it multiplies very poorly.

5. Hessian fly larvae were not found on the following; brome grass (B. erectus), meadow fescue (Festuca pratensis), tall oat-grass (Arrhenatherum elatius), timothy grass (Phleum pratense), steppe fescue (Festuca sulcata), cocksfoot (Dactylis glomerata), meadow-grass (Poa sp.) and green bristle-grass (Setaria viridis). On Agropyrum pectiniforme and A. repens a considerable number of the larvae perish before cocoon formation.

6. The hessian fly does not proceed to egg laying on grasses immediately after the appearance of the shoots, as happens on shoots of wheat, but 25-30 days after the appearance of the shoots. The poorly developed leaves of grass in the first 3 weeks following their appearance do not attract the flies. Hence when these grasses are sown in mid-August they are very lightly infested with flies, while winter wheat sown at the same times, as we know, is very heavily attacked.

7. Grasses may give high yields of hay and seed even when heavily infested with larvae (28-38% of the stems). The main danger does not reside in the amount of damage done to the grass by the hessian fly, but in the fact that grasses (Agropyrum tenerum, Clinelymus sibiricus and Roegneria fibrosa) become breeding centers of the flies which then migrate from the grass sowings on to the wheat shoots and inflict great damage on them.

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THE SOIL-INHABITATING INSECT PESTS INJURIOUS TO THE FOREST-TREE NURSERIES IN THE UKRAINE

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The species composition of the pests of forest-tree nurseries has repeatedly been the subject of research by many authors (Kelus, 1935; Stark, 1936; Nikol'skii, 1936, 1937; Berezina, 1949; Andrianova, 1950-1952, and others). They all agree that, on the whole, the chief loss of seedlings due to pests is brought about by cutworms and underground insects such as are commonly found in agricultural practice. Injuries from leaf-cutting and sucking insects rarely reach mass proportions and are not widely distributed.

The investigations carried out by us in the Ukraine in 1949 showed that more than 80% of the reported damage to seedlings and saplings was caused by soil-inhabiting insects. Consequently, for the protection of forests the study of these insects if of paramount interest.

METHODS

The work was carried out in six forest-tree nurseries.

1. Izyum Agriculture-Forestry Nursery. Situated near the Izyum station. Established in 1937. Surface elevations of nursery slightly undulating. Soil—the normal black earth. Diggings carried out in the forest—seed section, the area of which was 40 hectares. This section adjoined gardens and the fruit-growing section. Protective belts of wild olives stretched along the east and west sides. The agricultural practice in the nursery was found to be satisfactory except for some fallow land which was not sufficiently cultivated and, consequently, was badly overgrown.

2. Alekseevsk Nursery. Situated to the north of the steppe zone in Khar'kov region near Likhachevo station. Soil—the normal black earth. The nursery is situated on the southern and northern slopes of a valley, the bottom of which was planted with trees in 1934 at the time the nursery was established. From 1941-1944 the nursery was not used and the land became waste and overgrown. In 1949 the agricultural practice was unsatisfactory as a result of which pests were numerous.

3. Artemovsk Nursery. Situated in Stalinsk region near Artemovsk station. Established in 1914 but its area was increased in 1930 and again in 1948. Soil—the normal black earth. Surface elevations slightly undulating.

4. Komarovsk Nursery. Located in Khar'kov region in the very northern steppe zone on the sloping sides of a valley. Soil—the normal black earth. Nursery established in the year of inspection (1949) which was carried out at the end of April on the area planted out with forest-tree seedlings. The land was fallow or devoted to agricultural crops in 1948.

5. Babaevsk Nursery. The only nursery we inspected in the southern wooded steppes. Located in the Khar'kov region. Soil—the normal black earth; surface elevations gently undulating. To the north and south the nursery is adjoined by oak woods. Nursery established in 1949 and up to that time the land was under agricultural crops.

6. Mavrinskii Nursery. Situated near the town of Pavlograd, Dnepropetrovsk region on the banks of the river Volch'ei. Soil on the greater part of the nursery the normal black earth, but a portion of the nursery near the river was situated on sandy loam. From 20 hectares under afforestation, plots with thinned or weak saplings were inspected.

The first five nurseries were inspected in 1949, the remaining one in 1950. Besides this, pits were dug, 0.5 x 0.5 m in area and from 0.5-1m deep, according to the season. In all, the pits numbered 1082.

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Species Composition of the Pests

As a result of the diggings in 1949 thirty-nine species of pests of seedlings and saplings were observed:

Microporus nigrita F.
Lethrus apterus Laxm.
Pentodon idiota Hrbst.
Maladera holosericea Scop.
Amphinallon solstitialis L.
Rhizotrogus aequinoctialis Hrbst.
Rh. vernus Germ.
Melolontha melolontha L.
Anisoplia austriaca Hrbst.
Tropinota hirta Poda
Selatosomus latus F.
Agriotes gurgistanus Fald.
A. sputator L.
Podontha daghestanica Reitt.
Omophlus proteus Kirsch.
Tentyria nomas Pall.
Blaps lethifera Marsh.
B. halophila Fisch.
Platyscelis gages Fisch.
Crypticus quisquilius L.
Pedinus femoralis L.
Opatrum sabulosum L.
Gonocephalum pusillum F.
Cylindronotus arboreus All.
Helops sp.
Otiorrhynchus ligustici L.
Sitona collosus Gyll.
Sitona sp.
Psalidium maxillosum F.
Tanymecus palliatus F.
Bothynoderes punctiventris Germ.
Pachycerus madidus Oliv.
Chromoderus fasciatus Müll.
Cleonus piger Scop.
Mecaspis alternans Hrbst.
Lepirus capucinus Schall.
Lixus subtilis Sturm.
Euxoa segetum Schiff.
Feltia exclamations L.

Besides these, numerous harmless insects were caught [dung beetles, black beetles (Histeridae), ground beetles (Carabidae), dipterous larvae] and some pests normally found on agricultural plants. These are not included. All the Harpalinae found capable of damaging seedlings and young plants are given in the following list:

Amara ingenua Dft.
A. Apricaria Payk.
A. crenata Dey.
Ophonus pubescens Müll.
O. calceatus Dft.
Harpalus aeneus F.
H. psittaceus Geoffr.
H. smaragdinus Dft.
H. hirtipes Panz.

The insepction of the Mavrinskii nursery in 1950 added only one more species—Agrotis c-nigrum. L.

Location Frequency

By location frequency V. V. Alekhin (1925) and V. N. Beklemishev (1931) imply the percentage of samples or quadrats in which the given species occurs out of the total number of samples or quadrats taken in a given biocenosium. The number of specimens in a sample is not taken into account. By location frequency we mean the percentage of forest nurseries in which a pest is found out of the total number of forest nurseries inspected. Moreover, in order to arrive at strictly comparable results, the counts from the Mavrinskii nursery, where the inspection was carried out a year after all the others, are not taken into account, either here or in what follows.

Calculated in this way the location frequency is given in Table 1, from which it is seen that only about half the total number of pests is found in no less than four out of five nurseries.

TABLE 1

Location Frequency of Pests according to Nurseries

Number of nurseries in which species is found	Location Frequency	Number of species	Percentage species
In five nurseries	100	7	18.0
In four nurseries	80	9	23.1
In three nurseries	60	7	18.0
In two nurseries	40	6	15.4
In one nursery	20	10	25.6
Total		39	100

The species were as follows:

M. nigrita	P. daghestanica
L. apterus	P. gages
M. holosericea	O. sabulosum
A. solstitialis	G. pusillum
R. aequinoctialis	Sitonia sp.
A. austriaca	P. maxillosum
A. sputator	T. palliatus
A. gurgistanus	E. segetum

The distribution of pests not only on the nurseries but on the stations was of great interest. By station we mean a similar region of agricultural land sown with one crop and similarly worked. The location frequency according to station is calculated as in the preceding instance.

Out investigations in 1949 were concerned with the following species of trees: oak, maple, ash, acacia, fruit trees and brushwood. Besides this, areas in the nurseries which were treated as fallow or waste land, or sown with an agricultural crop at the time of the inspections, were also included. It appeared that 18 species, that is, almost half the total number of species, were met with on 5-10 stations (Table 2) and 7 species were found everywhere.

TABLE 2

Location Frequency according to Stations

No. of stations on which species are found	Location frequency, %	No. of species	Percentage species
On one	11.1	8	20.5
On two	22.2	8	20.5
On three	33.3	2	5.1
On four	44.4	3	7.7
On five	55.6	2	5.1
On six	66.7	4	10.3
On seven	77.8	1	2.6
On eight	88.9	4	10.3
On nine	100.0	7	18.0
Total		39	100.0

The following are the species met with on 8-10 stations:

M. nigrita	O. sabulosum
A. solstitialis	G. pusillum
R. aequinoctialis	P. maxillosum
A. gurgistanus	T. palliatus
A. sputator	E. segetum
P. gages	

All these are included in the list of pests encountered in 4-5 nurseries (see above). In other words, the pests met with in the majority of stations are also found in the majority of nurseries.

The Abundance of Pests

By abundance is implied the number of individuals found in unit area. We estimated it on 1 m^2. The over-all abundance is the sum of the abundances of all species in a given biocenosium or taken into account at a given investigation. The specific abundance of a species, or a group of species, is the percentage obtained by dividing the abundance by the over-all abundance.

TABLE 3

Abundance of Pests on 1 m^2

Nursery	Time of digging	No. of species	Over-all abundance	In species number having location frequency of 80-100%	
				abundance	specific abundance
Izyum	Spring	17	9.8	9.2	94.4
	Summer	21	7.1	5.5	78.5
	Autumn	21	4.8	3.7	77.8
Alekseevsk	Spring	19	19.3	19.0	98.1
	Summer	23	20.2	18.4	90.8
	Autumn	13	11.7	10.4	89.7
Artemovsk	Summer	15	2.7	2.6	96.7
	Autumn	16	3.5	3.0	84.4
Komarovsk	Spring	22	22.9	21.2	92.7
Babaevsk	Spring	10	2.2	1.7	77.4
	Average				88.0

From a consideration of Table 3 one can easily come to the following conclusions: first, the chief pests (averaging 88% in abundance) include widely distributed, "common" pests with a location frequency of 80%; secondly, the over-all abundance of pests is determined principally by the abundance of a few basic pests and depends very little on the number of species.

Correlation of Species Composition

The similarity or difference in species composition of two or a number of associations is readily estimated by the coefficient of correlation of species composition which represents among the number of species found in both associations, the percentage of species common to the two associations. According to Alekhin (1925) this coefficient is found from the following formula: $\frac{V_3}{V_1 + V_2 + V_3} - 100\%$ where V_1 = number of species in the first association, V_2 = the number of species in the second association and V_3 = the number common to both associations. If there are more than two associations then the coefficients are estimated between all the associations

taken in pairs and from the results the average is estimated by the formula: $\frac{2 \times 100\%}{N(N-1)} \sum \frac{V}{V_1 + V_2 + V_3}$, where the symbols are the same, but N = the number of associations. In our investigations it was found that the average coefficient of correlation of species composition of the pests among individual nurseries was equal to 49.8%. In this calculation the Mavrinskii nursery was not included.

The correlation of species composition found in the various stations of the nurseries are shown in Table 4.

TABLE 4

Correlation of Species Composition of Pests Met with in the Various Stations

Name of station	No. of species	Average coefficient of correlation with other station
Oak seedlings	17	53.2
Acacia seedlings	19	51.1
Maple seedlings	18	57.6
Ash seedlings	18	58.7
Brushwood seedlings	25	52.8
Fruit tree seedlings	14	55.6
Fallow	26	52.8
Agricultural crops	23	62.0
Waste land	20	42.4
Average		54.0

As is easily seen, the average is very high.

DISCUSSION OF RESULTS

Before commenting on what has been said we examined the results of the investigations made on the Mavrinskii nursery. It is found that the correlation of species composition with the rest of the nurseries amounts, on an average, to 31.7%. The species found in 1949 in 4-5 nurseries amounts to a figure of 72.7% of the overall abundance. In other words, the investigation of the Mavrinskii nursery completely confirmed the data of 1949 as to the very great similarity of the composition of the pests of nurseries.

Such uniformity of the species composition of anthropogenetic biocenosia is already found in the literature, for example, in a wheat field (Bei-Bienko, 1939). The uniformity of species composition of soil animals on similar soils is noted by Gilyarov (1949), who explained it correctly by the uniformity of the environment.

This specified rule (uniformity of species composition of the soil pests of nurseries) is better expressed within the limits of one climatic zone. In fact, out of five nurseries examined in 1949, four were situated in the steppe zone and one (Babaevsk in the southern wooded steppes. According to species composition of pests this latter nursery amounts to an isolated field which is clearly seen from the following figures. The coefficient of correlation of species composition for the four nurseries amounts to an average of 61.2%, but the coefficient between Babaevsk and the remaining nurseries has an average of 32.7%. From Table 3 it is seen that the overall abundance of the most common species in Babaevsk nursery is lower than for the others. And, in spite of everything, the uniformity of the insect pests in all the given nurseries is very high which gives us the right to consider this fauna as a part of a composite biocenosium, the biocenosium of the cultivated field. The composition of the edaphona (soil-inhabiting animals) of such a biocenosium is determined, in the first place, by the nature of the soil and depends little on the composition of the vegetation; this is accounted for by the fact that the pests are polyphagous. The polyphagous nature of these soil animals, corroborated by the data of Table 4, depends upon the environment, since for oligophagous or monophagous insects the search for food in such a dense medium as soil would be too difficult. The composition of the zoophagous insects is determined, in its turn, by

the composition of the polyphagous species. In this way, the composition of the whole edaphona is determined all things considered, by the nature of the soil (its composition, structure, humidity, treatment, etc.). Of course, soil animals compose only a part of the whole biocenosium which includes plants and animals living on the soil, on plants, etc. Naturally, these organisms, particularly plants, depend upon the nature of the soil.

All this leads to the conclusion that the species composition of the soil pests of nurseries is quite stable with regard to individual species and for the various nurseries situated on similar soils.

As a result, the development of pest control measures is greatly simplified and data obtained from one nursery can be safely used on another, at least, within zone boundaries.

SUMMARY

1. The main pests injurious to forest-tree nurseries are soil-inhabiting polyphagous insects, including both rhizophagous species, cutworms and other "cutting" insects.

2. The species composition of soil-inhabiting pests of nurseries planted on similar soils is very constant.

3. The species composition of soil-inhabiting pests injurious to seedlings of different tree species is also very constant.

4. The most eurytopic species are the most abundant.

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AMBLYMERUS SP. (HYMENOPTERA, CHALCIDOIDEA), A NEW INSECT PEST INJURING THE OVARIES OF HUNGARIAN BROME (BROMUS INERMIS LEISS)

Z. Ya. Agafonova

In the autumn of 1956, on the Kursk State Agricultural Experimental Station, it was noticed that the ovaries of the Hungarian brome (Bromus inermis Leyss.) variety Kamenno-Stepnoi 2, were damaged to the extent of approximately 40%. On the external scale of the flower, at the level of the ovary, round flight holes, about 1 mm in diameter (Fig. 1), were observed.

On cutting open such "seeds" colorless or yellowish membranes were found side by side with the dried up, undeveloped ovary and three brown stamens.

When the seed of the 1956 crop of Bromus inermis was examined bright green insects of the superfamily Chalcidoidea were encountered.

These chalcids were also found when dissecting seeds having no flight holes; the ovary was undeveloped and stamens were present, but on the ovary a yellow cocoon containing an adult insect, pupa or larva was seen. According to a preliminary determination by M. N. Nikol'skii the insect is a species nearly related, or identical to, Amblymerus* graminum Hårdh from the family Pteromalidae. The adult insect, as well as the larva, is exceedingly like the species describec by the Finnish entomologist Hårdh (1950), who observed its development in the stems of summer wheat in the western part of Finland.

The species with which we are concerned hibernates as a fully grown larva, rarely as a pupa, in fallen seeds in the field. When hibernation takes place in stores, where conditions of temperature and humidity are different, the insects were found hibernating during February-April, 1956, mostly as pupae, rarely as fully grown larvae or adult insects.

The first emergence of an adult insect under laboratory conditions was observed in the middle of April, 1957 at a temperature of + 17°C. Single individuals emerged in the field from young crops of brome on the warm sunny day of March 17, 1956 and continued until September. Very small, transparent larvae of the chalcid, 0.3-0.5 mm long, were first met with at the base of unfertilized ovaries on June 5, 1957. Two or three days later the larvae had increased notably in size, the segmentation of the body had become marked and the color had turned brown followed by yellow.

The larvae fed on the outside of the ovary (Fig. 2). At the point where feeding was taking place a depression was noticed which increased in size with the growth of the larva. During the feeding period, the larva is found on the ventral surface of the ovary. When feeding is completed the fully grown larva swings itself round to the upper surface of the exhausted ovary, head toward the middle of the flower, and proceeds to wrap itself up in a dense, ribbed, yellow cocoon which is almost equal in size to the shrivelled ovary and difficult, at first, to distinguish from it. The stigma dries up and is closely to the ovary (Fig. 3). It is said that flower infection goex on until pollination because, as a rule, the stigma falls off the fertilized ovary. Among the many thousands of flowers and seeds of B. inermis examined only once was a similar, yellow cocoon found elsewhere than on the

*The most recent author (Graham, 1957) considers the generic name Amblymerus Walker (1834) synonymous with Platymesopus Westwood (1833).

Fig. 1. Spike of brome with flight holes of chalcid.

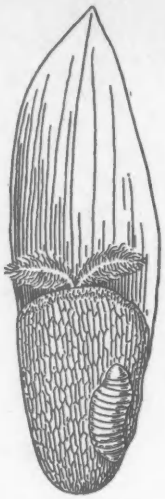

Fig. 2. Small larva on the ovary.

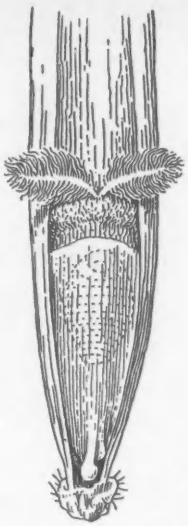

Fig. 3. Adult larva in cocoon.

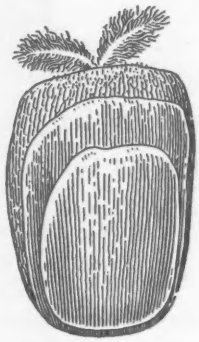

Fig. 4. Two cocoons on one ovary.

ovary and this was on the developing seed, near the embryo. The cocoon and the larva inside were a little smaller than the usual size. Only in one instance were two cocoons of different sizes found near the ovary (Fig. 4).

When examined under the microscope, it is evident that the cocoon is not of plant origin: it consists of thin, interwoven threads. Up to the present the whole process of cocoon formation has not been followed, although observations were made on fully grown larvae of the chalcid, isolated from the ovary and emitting from the anal aperture an amber colored liquid which, later, formed long, wax-like threads. Slowly turning around, the larva covered itself with a network of these threads.

The body of the larva is 1.5-2 mm long and 0.3-0.6 mm broad and consists of 13 segments, not counting the head. The head is small, slightly conical and partially drawn into the first thoracic segment, with the mouth on the ventral surface; mandibles weakly sclerotized, scarcely distinguishable. The larva differs from the typical chalcid larva in the setting of the spiracles on mammiform projections which are well marked in the young larva along the sides of the body, particularly on the 1st and 4-12th segments (Fig. 5). On the cuticle of the boiled and extracted larva spiracles are observed on all 12 segments of the body, except the anal segment, which is in the form of a small, round plate, as is typical in chalcid larvae (Fig. 6). The presence of 12 pairs of spiracles is unusual in fully grown chalcid larvae in which no more than 9 are found situated on the 2nd-10th segments of the body, but in the larva of A. graminum Hårdh the author also describes twelve.

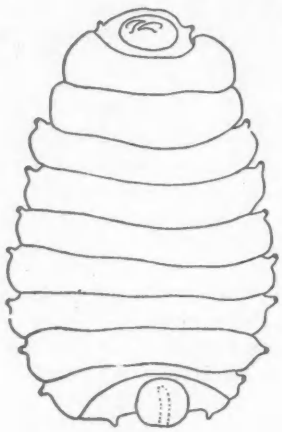

Fig. 5. Adult larva of chalcid taken from cocoon.

The pupa is of the usual chalcid type. Before escaping, the adult insect gnaws a flight hole through the outer scale of the flower. Seeing that in the brome spike one flower develops upon another (tile-like structure) so the insect from the upper flower has to bore through both scales of the lower flower.

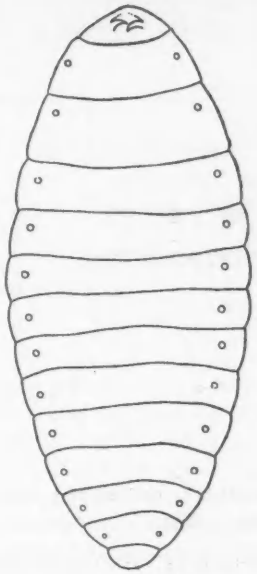

Fig. 6. Cuticle of boiled and extracted adult larva.

Apparently there are two generations a year because two maxima were observed in the numbers of insects—at the end of May and the middle of August.

Our species was observed not only in flowers of B. inermis Leyss., distributed in districts of the Kursk region, but also in the flowers of another species—Bromus riparius Rehm.

The chalcid was not observed in the wild species of rye brome (B. secalinus L.). It was also not found either in the stems of brome or in the stems or ears of winter rye, winter and spring wheat and barley, oats, timothy grass or fescue.

The chalcid Tetrastichus sp. also emerged from the seeds of B. inermis; it is, possibly, a parasite of the described species or of the larva of a cynipid damaging the undeveloped seeds. A description of the damage perpetrated by the latter insect will be published separately.

The described instance of ovary damage in the flower of B. inermis by pteromalid larvae appears, as yet, to be the second example, after Amblymerus graminum Hårdh , of phytophagous habits in this family.

The appearance of plant feeding in the family Pteromalidae and, in particular, in the representatives of the genus Amblymerus, as M. N. Nikol'skaya confirms, is undoubtedly, of comparatively distant origin.

In conclusion I express my sincere gratitude to M. N. Nikol'skaya for her ready assistance in this work.

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ON THE CONDITIONS DETERMINING THE DIAPAUSE OF THE HIBERNATING PUPAE IN CHLORIDEA OBSOLETA F. (LEPIDOPTERA, NOCTUIDAE)

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The question of the hibernation and diapause of the cotton moth has been studied by a number of authors (Kozhanchikov, 1938; Lozina-Lozinskii, 1941, 1949; Rodd, 1953; Goryshin, 1953).

It is well known that the pupae of this pest hibernate in a state of diapause. Kozhanchikov observed that warmth had an important action upon the development of the pupa in the hibernating as well as in the summer generations. Lozina-Lozinskii (1941, 1949) showed that duration of diapause in the cotton moth was not regular but fluctuated from one to many months and could extend beyond a year. For Central Asian conditions Rodd (1953) established that during years of mass outbreaks hibernating stocks consisted predominantly of diapausing pupae.

A few authors (Goryshin, 1953; Ditman, Weiland and Guilljr 1940) have studied the causes leading to diapause in the cotton moth. Goryshin (1953) showed that the principal cause of the autumn diapause in the pupa of the cotton moth in northern Caucasia appeared to be the seasonal changes in the length of day. From his data it follows that all caterpillars developing in autumn must give rise to diapausing pupae. Foreign authors (Ditman, Weiland and Guilljr, 1940) subscribe to another opinion concerning the origin of diapause in this species. From their observations it appears that the pupal diapause is brought about by the low temperatures prevailing during the period of larval development. By their results they explain the fortuitous appearance of diapausing pupae during cold spells in summer time and also the fact that the autumn population of the cotton moth always has the tendency to go into diapause.

In spite of a number of special researches into the question of hibernation and diapause in the cotton moth, much remains obscure. Our investigations were not concerned with the biology of the pest, which is dealt with in the literature, but aimed at explaining the conditions of variation in the composition of the overwintering stocks and the cause of pupal diapause which is of practical importance.

The investigations were carried out under field conditions during the three summer periods from 1952 to 1954 in the Azerbaidzhan SSR and in 1955 in the Ukraine; also during the winters of all three years in Leningrad in the All-Union Institute for Plant Protection.

Formation of Hibernating Stocks of the Cotton Moth in Azerbaidzhan and in the Ukraine

The results of our investigations in Azerb SSR during the three summers (1952-1954) showed that under natural conditions diapausing pupae begin to appear from the second half of September; all larvae pupating earlier than this date produced moths and were of no importance to the hibernating stocks. The percentage changes in numbers of diapausing pupae in relation to date of pupation in Azerbaidzhan in 1953 and 1954 are given in Tables 1 and 2.

TABLE 1

Dynamics of the Appearance of Diapausing Pupae of the Cotton Moth under Natural Conditions in AzerbSSR (Mugan') in 1953.

	Date of pupation						
	12-18 IX	19-30 IX	1-8 X	9-10 X	11-12 X	13-14 X	15-17 X
Total pupae	25	62	33	47	67	76	84
Percentage diapausing pupae	40	67.7	63.6	83.0	61.2	65.8	48.8

Diapausing pupae appeared on the cotton plant in 1953 from the first half of September. Toward the end of this month and during the beginning of October the percentage increased steeply. In 1954, among insects pupating between October 1 and 10, 90-92% were in a state of diapause. In 1953 the maximum percentage diapausing was considerably lower (65-83%). At later dates the percentage of diapausing pupae falls (45-48%). Not once in Azerbaidzhan was it recorded that all pupae of the cotton moth were diapausing. This helped in finding the connection between the duration of diapause and the survival of pupae during hibernation. In Tables 3 and 4 the duration of the pupal period is determined among the hibernating stocks from material gathered from the cotton fields at various times during the autumns of 1953 and 1954.

An analysis of the material given in Tables 3 and 4 shows quite a large range in the periods of pupal development. It is quite possible to separate the nondiapausing pupae, developing in the normal period (10-20 days) from those pupae lagging behind in development for considerably longer than 30 days. A few were in a resting condition for 50-80 days; for others a still longer period (100-200 days) was characteristic.

Caterpillars collected on one and the same day produced pupae showing the same range of variation in development period. However, long-diapausing pupae (100-200 days) were recorded only among those pupating during the second half of September and the first days of October.

For insects pupating at a much later date the duration of diapause decreased to 30-100 days. It is especially interesting to note that at the end of the pupation period (end of October) the number of pupae exhibiting a short diapause only, or even none at all, again increases.

TABLE 2

Dynamics of the Appearance of Diapausing Pupae of the Cotton Moth under Natural Conditions in AzerbSSR (Mugan') in 1954

	Date of pupation												
	14 IX	15—19 IX	20—22 IX	23—26 IX	27—30 IX	1—2 X	3—5 X	6—7 X	8—9 X	11—12 X	13—15 X	17 X	18—20 X
Total pupae	8	11	20	50	70	106	130	83	100	113	49	36	11
Percentage diapausing pupae	12.5	54.6	75.0	73.6	83.8	92.0	89.1	81.4	90.7	88.9	73.4	55.6	45.5

Similar data on the duration of the development of diapausing pupae were obtained in 1953 (Table 3). The difference in hibernation of the cotton moth stock in 1954 resulted in a much longer diapause reaching in a few individual instances, up to 212 days. In 1953 the period of diapause did not exceed 100 days.

TABLE 3

Duration of Pupal Period in Hibernating Stocks of the Cotton Moth in AzerbSSR in 1954 (field material at 23-25°)

Date of pupation	No. of pupae in expt.	Duration of pupal period					
		10—20 days	21—30 days	31—50 days	51—80 days	81—100 days	101—170 days
		in %					
12—15 IX . .	11	45.4	9.1	—	36.4	9.1	—
16—18 IX . .	14	64.3	—	—	21.4	14.3	—
19—22 IX . .	22	22.7	—	—	31.8	45.5	—
23—30 IX . .	40	32.5	1.6	—	38.0	27.9	—
1—8 X . . .	33	15.8	21.5	29.1	24.8	8.8	—
9—10 X . . .	47	—	17.0	21.2	61.8	—	—
11—12 X . . .	67	—	38.8	40.3	20.9	—	—
13—14 X . . .	76	—	34.2	59.3	6.5	—	—
15—17 X . . .	84	—	51.2	33.3	15.5	—	—

The features observed in the formation of the hibernating stock in Azerbaidzhan were examined in other ecological-geographical conditions. The work was carried out in Zaporozh'ye district, Ukraine SSR from August 20th to October 20th. Most of the material was obtained in the village Rainovke, Priazovsk region, where a daily collection of caterpillars in the V-VI instars was made. One portion of the caterpillars collected was allowed to pupate in the laboratory at 20-23° and in natural light, the remaining portion was left in a breeding place in the soil for overwintering.

TABLE 4

Duration of Pupal Period in Hibernating Stocks of the Cotton Moth in AzerbSSR in 1954 (field material at 23-25°)

Date of pupation	No. of pupae in expt.	Duration of pupal period					
		10—20 days	21—30 days	31—50 days	51—80 days	81—100 days	101—200 days
		in %					
14 IX	8	87.5	—	—	—	—	12.5
15—19 IX	11	45.4	—	9.1	9.1	9.1	27.3
20—22 IX	20	25.0	—	5.0	5.0	20.0	45.0
23—26 IX	50	22.4	4.0	7.7	14.3	27.5	24.1
27—28 IX	27	14.8	3.7	14.8	29.7	18.5	18.5
29—30 IX	43	11.6	2.3	4.6	51.2	25.7	4.6
1—2 X	106	—	8.0	5.9	54.7	29.5	1.9
4—7 X	213	2.5	12.2	26.8	43.4	15.1	—
8—12 X	213	4.7	4.6	43.6	40.2	6.9	—
13—15 X	49	8.2	18.4	26.5	38.7	8.2	—
17—20 X	47	44.9	—	5.6	49.5	—	—

The dynamics of the appearance of diapausing pupae of the cotton moth from the material kept in the laboratory at 20-23° are given in Table 5.

Among the insects pupating during the first half of September it was noticed that up to 41% were in a state of diapause (a single instance was, evidently, noticed earlier). During the second half of September the number of pupae diapausing quickly increased and, at the end of the month, attained 97%. At the beginning

TABLE 5

Dynamics of the Appearance of Diapausing Pupae of the Cotton Moth in Zaporozh'ye Region USSR

	Date of pupation														
	1–15 IX	16–17 IX	19–20 IX	21–22 IX	23–24 IX	26–27 IX	28–30 IX	1–8 X	10 X	11–13 X	14–15 X	17–18 X	19–20 X	22 X	23–25 X
Total pupae	12	23	24	44	57	70	99	135	64	46	41	45	31	43	62
Percentage of diapausing pupae	41.7	56.5	70.8	86.4	94.7	97.1	97.0	97.0	100.0	100.0	95.1	86.7	87.0	79.1	74.2

of October there are days on which 100% diapausing pupae were observed. Pupation taking place much later (October 20 - 25) lowered the percentage of insects diapausing (down to 70%) which agreed with the data obtained in AzerbSSR.

The condition of material deposited, as caterpillars ready for pupation in breeding places in the soil is shown in Table 6.

For examination and further observation, pupae, which had sustained natural autumnal conditions at temperatures of 15-18°, were dug up on November 29th, 1955.

TABLE 6

State of Hibernating Pupae of the Cotton Moth on December 1-7, 1955 (data from digging operations)

Date of pupation	Total pupae	Condition			
		diapausing		developing	
		number	%	number	%
20-25 IX	68	35	51.5	33	48.5
26-30 IX	67	41	61.2	26	38.8
1-10 X	40	28	70.0	12	30.0
11-20 X	27	15	55.6	12	44.4

A number of the pupae taken out of the holes and showing signs of diapause (pigmented spots in the region of the eyes) began to develop quickly after being maintained for some days at 15-18°. The remainder continued in a state of diapause (Table 6).

In comparison with the pupae kept under laboratory conditions, the percentage of diapausing pupae found under natural conditions was somewhat lower. This could be accounted for by the reactivation of short-termed diapausing pupae.

In Tables 7 and 8 the results of investigations on the duration of pupal diapause in laboratory and soil experiments are given.

An analysis of the data given in Tables 7 and 8 shows variations in the duration of pupal development of the cotton moth both in pupae under laboratory conditions and in pupae taken from the soil. In both groups there were pupae which gave rise to moths in almost normal periods (30 days). A few pupae continued their state of rest up to 50-80 days; others continued for much longer periods (100-150 days. Only in solitary instances did the pupal period last more than 150 days.

TABLE 7

Duration of Pupal Periods in Hibernating Stocks of the Cotton Moth in Zaporozh'ye Region in 1955 (at temperatures 23-25°)

Date of pupation	No. of pupae	Developing		Diapausing			
		10—20 days	21—30 days	31—50 days	51—80 days	81—100 days	101—150 days
		in %					
1—15 IX	12	50.0	8.3	—	8.3	—	33.4
16—20 IX	47	19.2	17.1	2.1	6.4	12.6	42.6
21—24 IX	100	5.3	4.3	—	42.4	17.2	30.8
26—30 IX	164	2.5	0.5	1.5	54.6	3.9	37.0
1—8 X	134	—	3.0	3.8	55.9	14.2	23.1
10—13 X	105	—	—	20.3	52.5	18.1	9.1
14—18 X	84	—	9.4	21.5	51.4	12.9	4.8
19—22 X	65	—	16.6	26.9	33.2	23.3	—
23—25 X	59	—	20.4	28.8	35.6	15.2	—

Data from the analysis of the hibernating stocks in the Ukraine (1955) and in Azerbaidzhan (1952-1954) shows that the material is quantitatively different in these republics and consists of nondiapausing, together with short-termed diapausing and long-termed diapausing pupae.

Conditions Regulating Diapause in the Cotton Moth

In the literature one finds very little information on the origin of diapause in the cotton moth. The cause of diapause may be bound up with the various factors making up the external environment, of which food and the daylight factors seem to attract the greatest attention (Less, 1955; Danilevskii 1956).

In our experiments in AzerbSSR from 1952 to 1954 and in Leningrad in 1955 we also determined the connection between the onset of diapause and the daylight period.

It is not known to what degree the photoperiodic reaction of the cotton moth depends on temperature and feeding. The question with regard to temperature was investigated in 1954 in two series of experiments (one in Baku in 1954, the other in Leningrad in 1955) in which the influence of a short day, in combination with various temperatures, on the onset of diapause in the pupae of the cotton moth was determined.

TABLE 8

Duration of Pupal Periods in Hibernating Stocks of the Cotton Moth (pupae taken from the field November 29, 1955)

Date of pupation	No. of pupae on 29XI	Temperature conditions of pupae after taking from soil		Pupal period in days (number of pupae in %)					
		from 29 XI to 5 XII	from 6 XII	10—20 days	21—30 days	31—50 days	51—80 days	81—100 days	101—150 days
				%	%	%	%	%	%
20—25 IX	68	15—18°	23—25°	—	—	—	—	67.7	32.3
26—30 IX	65			—	—	—	21.5	47.7	30.8
1—10 X	39			—	—	—	53.8	30.8	15.4
11—20 X	26			—	—	34.6	57.7	7.7	—

TABLE 9

Influence of Light Conditions during the Period of Larval Growth on the Diapause of Cotton Moth Pupae at Temperatures of 25-28° in June, 1952

Natural daylight (14 hr 45 min—15 hr 00 min)			8-hour illumination			10-hour illumination			12-hour illumination		
number of pupae in experiment	emerging moth (in %)	diapausing pupae (in %)	number of pupae in experiment	emerging moth (in %)	diapausing pupae (in %)	number of pupae in experiment	emerging moth (in %)	diapausing pupae (in %)	number of pupae in experiment	emerging moths (in %)	diapausing pupae (in %)
83	100	0	48	54.1	45.9	30	60.0	40.0	31	77.4	22.6

Eggs, laid by the cotton moth, were placed in the compartments of a multithermostat at various temperatures (30, 25, 23 and 18°). In each compartment one portion of the eggs was kept in the dark for a given time, the other portion remained in natural daylight. The caterpillars from the first instar until pupation were maintained at one and the same temperature and illumination. The caterpillars in both series of experiments were fed on tomato leaves.

The results of the investigations on the influence of temperatures on the diapause of the cotton moth are given in Tables 10 and 11. The short day had its greatest effect at about 23°. Under these conditions almost every pupa diapaused. Much higher and much lower temperatures reduced the effect of a short day. It was interesting to note that under the condition of a short day the duration of diapause decreases with drop in temperature. These results conform to the results derived from the field investigations (Tables 3 and 4).

In order to determine the role played by food on the regulation of diapause, the caterpillars were reared, during the summer and autumn of 1953, on various foodplants (cotton, tomato and lucerne leaves, Table 12) under the restricted light of a short day.

The percentage of pupae diapausing under a 10-hour day in summer at the high temperature (26-28°) was considerably lower than in autumn at the lower temperature of 23°. No diapausing pupae were observed under the conditions of a long day.

The percentages of diapausing pupae arising from insects fed with tomato and cotton leaves were approximately equal. Insects fed on lucerne produced a considerably lower number of diapausing pupae.

TABLE 10

Action of Temperature on the Diapause of the Cotton Moth under the Condition of a Short Day (Baku, 1954).

Temperature of expt. (average)	Date of expt.	Initial stage of expt.	Natural daylight in hours (14-45 15-00)			10-hour illumination			Average duration of diapause (in days)
			total No. of pupae	emergence, %	diapause, %	total No. of pupae	emergence, %	diapause, %	
30.1°	25—30 V	Eggs and first instar caterpillars	28	100	0	25	92.0	8.0	76 (85—68)
25.6°	»	The same	38	100	0	24	58.4	41.6	53 (107—37)
23.3°	»	»	46	100	0	22	18.2	81.8	38 (54—31)
19.0°	»	»	30	100	0	24	75.0	25.0	29 (43—24)

TABLE 11

Action of Temperature on the Diapause of the Cotton Moth under the Condition of a Short Day (Leningrad, 1955)

Temperature of expt. (average)	Date of expt.	Initial stage of expt.	Natural daylight in hours (18-13—18-46)			8-hour illumination			Average duration of diapause (in days)
			total pupae	condition		total pupae	condition		
				developing (in %)	diapausing (in %)		developing (in %)	diapausing (in %)	
29.5°	30 V—10 VI	Eggs and first stage caterpillars	28	100	0	47	93.6	6.4	80.5 (84—77)
25.2°	The same	The same	31	100	0	45	37.8	62.2	68.7 (106—32)
23.1°	»	»	48	100	0	52	5.8	94.2	55.2 (142—32)
19.6°	»	»	22	100	0	24	66.7	33.3	41.0 (38—44)

TABLE 12

Influence of Food under Summer and Autumn Conditions (experiment 1953)

Illumination	Date of experiment	Initial stage in expt.	Number	Cotton leaves		Tomato leaves		Lucerne leaves	
				emergence, %	diapause, %	emergence, %	diapause, %	emergence, %	diapause, %
July, temperature 26-28°									
Natural illumination (14-59—14-19 hours)	29—30 VI		257	100	0	100	0	100	0
10-hour illumination	The same		257	67.4	32.6	55.5	44.5	92.9	7.1
September, temperature 23-24°									
Natural illumination (13-06—11-50) + 4 hours supplementary electrical illumination	2—3 IX	»	220	100	0	100	0	100	0
10-hour illumination	The same	»	220	27.8	72.2	38.9	61.1	75.0	25.0

SUMMARY

Field and laboratory studies on hibernation and diapause in Chloridea obsoleta F., carried out in various geographical localities and ecological environment, lead to the conclusion that the diapause in this species is controlled by the action of a complex of environmental factors, the principal factor being the seasonal changes in day length (which is in agreement with Goryshin, 1953). However, the effect of photoperiod is well marked only at temperatures 23°C. There are from 60 to 90 per cent of diapausing pupae at this temperature in Azerbaidzhan, while in the Ukraine all the pupae were observed to diapause. Both higher and lower temperatures reduced the proportions of diapausing pupae to the total number of hibernating pupae. Such an extraordinary response to low temperature has been previously recorded only in Laspeyresia molesta Busck (Dickson, 1949).

The food regime also has a certain (although relatively minor) effect on the initiation of diapause. These facts explain the heterogeneity of hibernating pupae with respect to the duration of the diapause, as well as the peculiar variations in the proportion of diapausing pupae in nature.

These variations in the proportion of diapausing pupae (caused by variations in temperature and in the time of development of the autumn generation), can have a great effect on the survival of hibernating pupae and determine the abundance of the pest in the following year.

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COENORRHINUS VITIS TER-MINASYAN. SP. N. (COLEOPTERA, ATTELABIDAE), A NEW PEST OF THE GRAPE IN THE MARITIME TERRITORY OF USSR

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Among the pests of the Amur grape, A. K. Bous observed large numbers of a weevil belonging to the family Attelabidae and producing considerable loss to the grape harvest. These weevils are related to the new species from the genus Coenorrhinus Thoms. a description of which is given below.

Coenorrhinus vitis Ter-Minasyan, sp. n. (Fig. 1)

Yellowish brown in color, covered, not thickly, with a fine yellowish pubescence which is directed forwards on the pronotum but backwards on the elytra. Head not larger than its breadth at the base, coarsely and fairly densely punctate, eyes moderately prominent, round. Rostrum (Fig. 2) long, in ♂ almost equal in length to the elytra, with a rather blunt, central keel reaching to the middle of the rostrum; each side of the rostrum is bordered, as far as the middle, by a much thinner keel. On both sides of the central keel of the rostrum are 1-2 rows of fairly coarse punctures. In the ♀ the rostrum is decidedly narrower and longer than that of the male, clearly longer than the elytra, curved, without central keel and with only weakly marked lateral keels; punctuation much less marked, rostrum more shining. Antennae in ♂ and ♀ inserted immediately behind the middle of the proboscis; it is much thicker in the ♂ and the joints longer, in the ♀ they are elongated. 1st-5th joints of antennae elongated, not less than three times as long as broad, the first two joints thicker than the rest; 6th to 7th joints only a little longer than half the 3rd joint, clearly broader at the distal ends; 8th joint considerably smaller than the joints of the club, not closely adjacent to the club, wider and shorter; joints of club almost equal in length among themselves, not close to one another. Prothorax wide at the base, its length almost equal to the breadth at the base, considerably contracted forwards and with distinct contraction in front of the vertex, markedly rounded side and narrow, elongated furrow along the middle, the whole thickly and fairly coarsely punctured. Elytra no less than 1 ½ times longer than the breadth at the shoulder, with a distinct, deep concavity on the anterior edge behind the scutellum, with deep, punctured grooves, the first short but distinct; areas between grooves narrow, raised and shining, covered with small

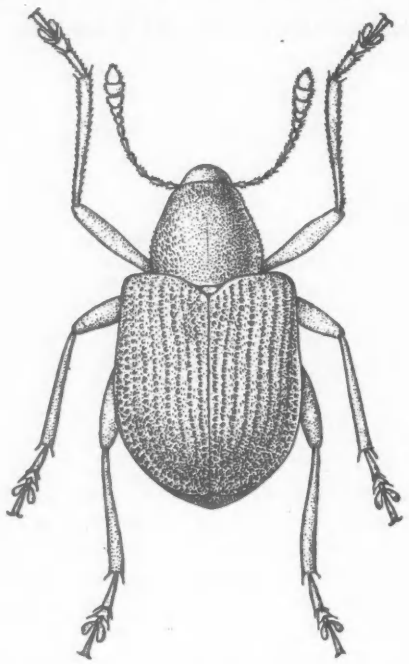

Fig. 1. Coenorrhinus vitis Ter-Minasyan, sp. n.

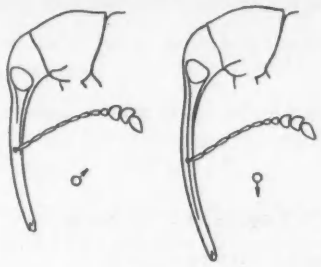

Fig. 2. Coenorrhinus vitis Ter-Minasyan, sp. n. Head in profile.

punctures; penultimate furrow unites with the last in the anterior third of the elytra. Pygidium pointed at the tip, densely punctured. Claws with powerful teeth. Length 4 mm (without proboscis).

Kraskino, Maritime territory (A. K. Bous). Holotype (♂) and allotype (♀) found in the collections of the Zoological Institute AN SSSR.

According to the observations of A. K. Bous the insect develops in the berries of the Amur grape: it does serious damage.

It is related quite closely to Coenorrhinus bisulcatus Voss. but differs distinctly from it in its over-all yellow-brown color, absence of a keel on the prothorax, fusion of the penultimate groove on the elytra with the last in the anterior part of the elytra, presence of distinct first groove and other characteristics.

COENORRHINUS VITIS T.-M (COLEOPTERA, ATTELABIDAE), A NEW PEST OF THE GRAPE IN THE MARITIME TERRITORY, USSR

A. K. Bous

To the old inhabitants of the Maritime territory engaged in gathering Amur grapes a small reddish brown colored insect, termed the "grape bug", was well known long ago as a serious pest of the grape harvest. Experienced collectors of the wild grape noticed that the grapes were considerably more damaged by this insect in localities which were more humid. The damage caused by the insect in the vineyards of the Maritime succulent fruit experimental fields was very noticeable after the introduction of vine culture into the Maritime territory.

In some years the damage caused by this pest is so great that when a further increase in the area under grape cultivation was envisaged a detailed study of the pests was an urgent necessity.

The scientific identification of the "grape bug" proved it to be a weevil of the family Attelabidae, genus Coenorrhinus, which was not known to science. Now it is described under the name Coenorrhinus vitis T.-M. (Ter-Minasyan, 1959: 361-362).

The weevil appears during the flowering period of the grape 12 VI-12 VII. Pairing takes place on the ground or on the grape inflorescence. The female bores a hole with the rostrum in the ovaries of the grape and lays one egg in the flesh near the seed embryo or else in the flesh itself. More than one egg may be laid in one berry according to the number of seeds the berry contains. If infested in the early period of development the ovaries blacken and shrivel up, together with the egg. For this reason sometimes the whole bunch of grapes dies. If infested at a later period the berries continue to develop. The larvae embed themselves in the seeds where they feed and develop. In the period between 20 VIII and 20 IX the adult larvae leave the berries through the original hole and fall to the ground. The larvae then descend into the soil to a depth of 12-14 cm. They overwinter in small cells. Pupation takes place in the soil in the following year between 10 VI and 30 VII. After pupation the beetle soon appears on the surface of the soil. When the grape berries become a little larger than a pea the beetle cannot bore a hole to the necessary depth into the seed. Consequently, the eggs deposited in a shallow hole die, but the little hole in the berry closes up and persists as a small, brown spot.

During unfavorable weather conditions when the flowering of the grape is not going on, the oviposition period of the beetle is drawn out. A dry spring is particularly unfavorable to the beetle. In 1958, in the Maritime territory, it was comparatively dry up to 20 VI. Because of this the blossoming of the vine occurred 15 days earlier than usual and at the time of the emergence of the vine weevil which, in 1958, appeared rather later than in 1957, i.e., about 15 VII, when the vine berries were already quite large and the beetle was unable, therefore, to do any serious damage.

On the author's farm an Amur grape vine was isolated for observation and its blossoming artificially delayed by mulching for 15 days. The appearance of the beetle coincided with the opening of the inflorescence. Consequently, all the ovaries were infested and 90% of the fruits destroyed.

Arising from the study of the life-history of the vine weevil the following measures for its control can be recommended:

1) establishment of vineyards on drier soil;

2) collection of beetles on bright days by shaking them off the vines into sheets 2-3 times a day and on dull days by picking them off with forceps; the collected beetles should be killed;

3) dusting the vines and surface of the soil with DDT dust at the time the beetles appear;

4) collection of larvae by shaking the vines at the time they are leaving the berries followed by their immediate destruction;

5) a two-stage turning of the soil to a depth of 12-15 cm—in autumn after harvesting with simultaneous application of 15 g BHC per square meter and in spring up to the time the insects begin to pupate (in May) with application of 10-15 g BHC per m^2;

6) loosening the soil to a depth of 6-7 cm after the larvae have left the berries and entered the soil and the application of 10 g BHC per m^2;

Among the pests of the grape vine, there is a whole series of species of weevils. Such, for example, are the snout beetles of the genus Otiorrhyncus, 17 species of which are detrimental to viticulture in various districts in USSR(Fedorov, 1938). In his resume, Stellwaag (1928) mentions fairly large numbers of weevils damaging vineyards in various countries. Among these pests are species of the genus Byctiscus: B. betulae L., is widely distributed in European-Siberian subregions, damaging the vine in southern Europe and in the European part of USSR, and also B.lacunipennis Jek. damaging vines in a similar manner in the Maritime territory. The damage perpetrated by these pests is very characteristic and cannot be confused with that done by Coenorrhinus vitis T-M.. According to Stellwaag (1928), damage similar to that done by C.vitis is inflicted on the wild and cultivated vine in the United States of America by the weevil Craponius inaequalis Say, belonging to the superfamily Ceuthorrhynchinae, which is remote from the Attelabidae and belongs among the true weevils (Curculionidae).

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SOME PECULIAR FEATURES OF THE BIOLOGY OF PAPILIO PODALIRIUS L. (LEPIDOPTERA, PAPILIONIDAE)

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Exhibition of Recent Research in National Agriculture USSR, Kiev.

The swallowtail, Papilio podalirius L., is a diurnal butterfly long known as a pest of fruit crops.

I was drawn to undertake a study of this insect by its appearance, in great numbers, in gardens at Kiev during the summer of 1955. Observations were continued through the spring, summer and fall of 1956.

By observing the development of the swallowtail, I discovered a number of peculiar features, indicating, more precisely, the details of its biology.

In the first place, the role of the swallowtail, as a pest, and the extent of its effect on plants of the family Rosaceae are not assessed with sufficient accuracy in the literature; according to the author's data, plants of this family are not all equally attractive to the swallowtail. In fact, the swallowtail larvae show the greatest preference for a very restricted group of plants, in the first instance, for the stone fruits (peach, apricot, Japanese quince, steppe cherry, alycha, sloe, plum and others). Such rosaceous species as the apple, pear, cherry, wild cherry, rowan and many others are rarely damaged by the swallowtail and then only to an insignificant degree.

The transfer to northern districts of more southern species of stone fruits (especially peach and apricot) and shrubs (Japanese quince, steppe cherry and others) helps to widen the distribution of this pest.

In Kiev, at the Exhibition of Recent Research in National Agriculture, regional and local varieties of peach and apricot are being cultivated. The following varieties of peach are being grown here—Kiev Early, Kiev Earliest, Glory of Kiev and others; also present are the following varieties of apricot—Nikitins'ka, Sorochins'-ka, Bairak (1738) and others. According to the rules of good horticulture, the cultivation of these varieties is to be recommended; nevertheless, the swallowtail larvae are encountered here every summer and do considerable damage. They feed on the young leaves of the uppermost twigs, nibbling the leaves along their margins and rejecting only the central vein. Damage of this kind greatly restricts the growth of lignin, as well as seriously reducing the assimilatory apparatus of the tree and the initiation and formation of fruit.

Under the conditions at Kiev and in northern districts of Ukraine, the swallowtail has one generation a year; only in particularly warm years, such as 1955, can it produce two generations.

According to the literature, the swallowtail imagines of these districts are on the wing during May and the beginning of June. According to my observations, the butterflies appeared in the second half of July and were on the wing until the first days of September.

I discovered certain distinctive features about the life habits of the larvae. For instance, they construct web-like membranes, usually in the middle of the leaf. These membranes, the so-called cushions, are frequently made by the larvae in cold, windy weather. The cushions are of an elliptical shape, whitish in color, practically water resistant, and help the larvae to maintain their hold upon the leaf.

On the arrival of favorable weather conditions, the larvae leave these cushions in search of young leaves. In persistently overcast weather, they remain on their cushions and eat the margins of the leaves on which they are resting. It is always easy to detect the presence of the larvae on a tree, since the cushions are very clearly visible, even at some distance.

While moving from place to place, the larvae maintain only a weak hold on the leaves and twigs and fall to the ground as the result of even a gentle vibration. The larvae therefore feed only in calm weather, in the morning or at night. They move as if feeling their way, waving the anterior part of the body from side to side.

Data on the cold tolerance of the swallowtail larvae are of some interest. Thus, subzero air temperatures were recorded at times in October, 1955, beginning on the 10th to 20th of that month. The swallowtail larvae, however, were unharmed by subzero temperatures of short duration, fed normally on the green leaves of the apricot and peach, and subsequently pupated under an average temperature of + 6 to 7°C. The fall of 1956 was colder than that of 1955; during this period, subzero temperatures were recorded as early as the first days of October and sometimes lasted all night and morning. Between the 15th and 20th of October, the average day temperature was only +3 to 5°C. However, this degree of cold and night frost was not sufficient to kill the swallowtail larvae. On the 21st and 22nd of October, during an inspection of Japanese quince bushes and twigs of apricot, etc., fully viable swallowtail larvae were discovered. As soon as the sun appeared and the temperature rose to + 6 to 7°C, the larvae continued to eat the young leaves of the uppermost twigs.

As regards pupation: it is indicated in the literature that the swallowtail larvae pupate on the food-plant. In reality, this is not so. I studied the pupation of the larvae over a period of several years, yet I never came across a pupa on peach, apricot or any other of the favorite food-plants, even when there had been many larvae on these. As has been indicated, the swallowtail larvae leave the food-plants and crawl over the ground, sometimes for a considerable distance, until they reach some thick brushwood, the base of which is full of dry leaves, grass, etc.

In such places, protected from wind, insectivorous birds, etc., the larvae pupate. Sometimes, a larva comes across a scrap of paper or some hay and pupates there; sometimes, it crawls under some old, dry bark on a stump, into a chink between planks, etc.

The winter of 1956 was remarkable for its severe frosts, the temperature at Kiev sometimes reaching –30°C and lower. Nonetheless, swallowtail larvae in experimental samples subjected to an equally low temperature were not killed. At the end of June in the following year, swallowtail butterflies emerged from the pupae derived from these experimental samples.

From these observations on the biology and harmful activities of the swallowtail, the need for a wide dissemination of data on this pest of the chief stone fruit species becomes evident.

The following measures against the swallowtail may perhaps be suggested.

First, in small stone-fruit plots, the egg batches, which are easily visible to the naked eye, should be destroyed. Young larvae will be killed together with the eggs.

It is possible to remove the swallowtail larvae from a tree by gently shaking it (without damaging the fruit), and then to collect them on the ground. The larvae are effectively destroyed by dusting or spraying the trees with DDT or Gammexane in the usual dosages. Spraying the damaged plants with intestinal poisons—sodium arsenite, Paris green etc. also gives good results.

STUDIES ON THE BIOLOGY OF SCOLYTUS INTRICATUS RATZ. (COLEOPTERA, IPIDAE) IN THE OAK-WOODS OF THE SAVALA FORESTRY (VORONEZH REGION)

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During the last three years, there has been considerable destruction of oak-woods in the Lipetsk estate area of the Savala forestry (Voronezh region). Beginning suddenly, in 1953, it quickly enveloped all the southern part of the estate. Destruction of the same type was also noted during the same period in the forest-steppe and forest zones. It has been established by Shcherbin-Parfenenko that the destruction of the oaks in these forests is due to their being attacked by a vascular disease. The cause of this disease is a fungus of the genus Ophiostoma, related to Cerastomella ulmi—the Dutch elm disease pathogen. These fungi were isolated from dead oaks in the Lipetsk estate in 1955, by Ivanchenko (1956). This suggested to her that the destruction of oak-woods in the Savala forestry, as well as in the southern forests, was caused by fungi of the genus Ophiostoma. It is known that insects act as vectors of vascular diseases. Thus, it has been established by numerous investigations that Dutch elm disease is carried by the bark-boring beetle Scolytus multistriatus Marsham, during its period of supplementary feeding on twigs of perfectly healthy trees (Fischer, 1928; Readio, 1935; Wallace, 1939; Collins, 1938, 1941). In addition to S. multistriatus, Dutch elm disease can be carried by other wood-boring insects—by the bark borers Hylurgopinus rufipes Eichh. (Collins, 1938) and Scolytus laevis Chap., by the weevil Magdalus armigera Geoffr., and by the longicorn Saperda punctata L. (Kalandra, Pfeffer, 1935). Extermination of these vectors is the only effective means of controlling Dutch elm disease (Bromley, 1948; Plumb, 1950; Matthysse, Müller Thompson, 1954; Pease, 1954, and others). This method must also be followed in developing control measures against vascular diseases of the oak. In this connection, the need became apparent for studies on the biology of the principal vectors of Ophiostoma spp.

The chief wood-boring insects affecting oaks in the Lipetsk estate are the bark borer Scolytus intricatus Ratz., the longicorns Plagionotus detritus L., P. arcuatus L., Mesosa myops Dalm., the weevil Gasterocercus depressirostris L., the urocerid Xiphydria prolongata Geoffr., and the buprestids Agrilus biguttatus F., A. angustulus Ill., A. hastulifer Rtzb. It has been shown by especially arranged studies that the longicorn imagines, having undergone their development in the oak, emerge with their eggs fully mature, do not require supplementary feeding, and consequently do not act as vectors of vascular disease. Larvae of most species mentioned inhabit only those trees which have been considerably weakened. Thus, (as is also the case with imagines of these species) they are not involved in the creation of new destruction-centers, even if the pathogenic fungi should develop in their tunnellings. The slender-bodied buprestids require supplementary feeding, but their nibbling of the leaves does not, apparently, suffice to infect the tree with vascular disease. The role of Gasterocercus depressirostris L. is obscure since it is not known where the beetles' supplementary feeding takes place. The urocerid imagines can carry vascular disease during the period of egg laying; this may occur on perfectly healthy trees. However, the most important vector of vascular disease in the Lipetsk estate is perhaps Scolytus intricatus Ratz. This suggestion, put forward by V. N. Stark, was confirmed by the preliminary investigations of Ivanchenko (1957). She isolated the pathogen from S. intricatus Ratz. imagines and from their nibble marks on branches of healthy trees.

TABLE 1

Degree of Infestation of Oak-Plantations by Larvae and Imagines of Scolytus intricatus Ratz.

No. of quadrat	Type of destruction	No. of flight-apertures per in^2	% of infected twigs
165	Intensive	25.0	51
166	"	24.0	35.3
186-188	"	29.0	10.0
195	"	31.7	34.7
170	Restricted	20.3	44.5
179	"	18.0	-

In this connection, the need for a study on the biology of S. intricatus became apparent; this was the object of the present investigation. The work was carried out during 1956 in the Lipetsk estate oak-woods (approximately 50 to 60 years old); these consisted, in most cases, of plantations of pure oak (summer and winter forms) without brushwood and undergrowth. Mixed stands of oak and birch exist only in a few quadrats (171, 172). Stands of natural origin with thick undergrowth are situated in quadrats 176, 173 and 185. A full investigation in the spring of 1956 showed that the destruction emanates from the southern part of the estate. At present in the Lipetsk estate, there are three separate centers where destruction is of the intensive type. In these centers, there are dead and weakened trees, and trees with their crowns dead or reduced. The number of dead trees averages 40 to 45%; of these about 10% were killed in 1953 and the rest during the next two years. In addition to these major centers, there are minor centers in four quadrats (170, 179, 183, 187). The initial stage of the attack —the appearance of trees with dead crowns and of a few dead trees—was noted also in quadrats 171, 180 and in winter-oak sections of quadrats 165 and 166. Stands of artificial origin experienced the heaviest destruction. Stands of natural origin are affected to a considerably lesser extent.

Our principal objects of study were details of behavior and feeding in the S. intricatus imago. The nature and locality of supplementary feeding were established by field observations, as well as laboratory experiments. With the object of discovering the feeding localities of S. intricatus imagines, we cut branches with thin bark in different plantations and from different parts of the tree-crowns.* Intensity of infestation was determined according to the percentage of infected branches. In the laboratory, the beetles were kept in enclosures of glass and netting. Food was changed every 3 to 5 days. The twigs were moistened with damp cotton-wool to prevent their drying up. The physiological condition of the beetles and the biochemical composition of the food were determined. Observations on the beetles' flight-dynamics were made in the forest and in the insectarium set up in quadrat 145. Logs, 1.5 to 2 m in length, were placed in the insectarium. In hot weather, the logs were moistened twice a day. Laboratory assistant P. T. Anufrieva took part in this work. Parallel with these entomological investigations, Yu. N. Ivanchenko carried out research on the pathogenic fungi.

In general terms, the development of S. intricatus is as follows. The beetles emerge in May and June. In 1956, the first beetles were found on May 16. After emerging from the pupa, they rest immobile in their tunnels for 10 to 12 days. During this period, they show no reaction whatever to the smell of food. When twigs are placed in the enclosures, the beetles do not react. Under laboratory conditions, the beetles did not begin to feed until May 26. In spite of the lengthy interval between the beetles' emergence from the pupa and their arrival at the surface, formation of their reproductive organs is delayed, and they fly away from the bark with ovaries undeveloped. Supplementary feeding of S. intricatus resembles that of S. multistriatus. It takes place on perfectly healthy trees—on branches with thin bark—and lasts 10 to 12 days. Like S. multistriatus (Parker et al., 1947; Collins, 1938, 1941). S. intricatus attacks the fine, terminal twigs at their nodes. To start with, the beetles

*Percentage of infected branches in all tables is given on the basis of examination of only those branches with thin bark.

TABLE 2

Degree of Colonization of Various Types of Oak-Plantation by Scolytus intricatus Ratz. Imagines, during Their Period of Supplementary Feeding

No. of quadrat	Locality of sample	Condition of plantation	No. of twigs examined	% of twigs infected
170	Focus of destruction center	Restricted destruction, killing 25 to 30% of trees	907	44.5
170	70 to 130 m from destruction center	Occasional dead trees	700	Occasional nibble marks
170	200 m from destruction center	Healthy stand	800	0
165	Focus of destruction center	Intensive destruction, killing 35 to 40% of trees	650	39.3
165	Periphery of destruction center	Occasional dead trees	700	9
165	Stand adjoining destruction center	Healthy stand	900	0

make superficial nibble marks; only after several days do they complete disappear into the interior of the twigs, making tunnels about 0.5 cm in length. Considerable quantities of bore-meal are extruded from the aperture. In the laboratory, the beetles do not discontinue feeding if the twigs dry up to some extent; however, they readily move over to fresh twigs if these are available. In the Lipetsk estate, in 1956, the beetles began to emerge on June 1, and at once started to feed. It is at this time that the first nibble marks appear in the forest. Eggs are laid during the second half of June and the beginning of July on thick boughs—less frequently on the trunks. Only weakened trees are attacked, so that damage caused by S. intricatus larvae is not of economic importance. The larvae pupate in the spring of the following year, at the end of April and beginning of May. Thus, S. intricatus differs from S. multistriatus in having one generation per year. S. intricatus has been recorded from all the

TABLE 3

Influence of Feeding-Intensity of Scolytus intricatus Ratz. Imagines on the Incidence of Vascular Disease

No. of quadrat	No. of tree	Nature of tree	Nature of branch	% of twigs infected
170	I	Dying this year; with newly withered leaves	Branch with withered leaves	95
170	I	The same	Branch healthy, green	4
170	II	Tree with disease symptoms	Diseased branch, with bright red leaves	100
170	II	The same	Healthy branch	1
170	III	Upper part of crown completely dead, many dead branches in lower part	Diseased branch, with bright red leaves	100
170	III	The same	Branch with few leaves	52.5
170	III	The same	Healthy branch	20.7
186	I	Tree at focus of destruction center; well-covered with leaves	Branch with yellowing leaves	55.5
186	I	The same	Healthy branch	21

TABLE 4

Distribution of Scolytus intricatus Ratz. Imagines in a Tree-Crown

No. of quadrats	No. of tree	% of twigs infected with S. intricatus in different regions		
		top	middle	base
195	I	75	15	14
166	I	60	33	28
166	II	66	50	40
165	I	4	0	0

destroyed plantations in the Lipetsk estate. Larvae and flight-apertures have been found in all three major centers, and also in quadrats 171 and 179, where the attack is of the restricted type (Table 1).

The beetles' nibble marks have also been discovered in these plantations. An average of 35.5% of the twigs show signs of their activity. Moreover, in those plantations where no trees have been killed, no nibble marks of S. intricatus are present. Thus, in quadrats 173 and 174, and in a series of other healthy stands, no signs of attack by S. intricatus imagines have been discovered. Within the limits of any one plantation percentage of twigs infected with S. intricatus corresponds with the degree of tree destruction. For example, in quadrat 170, at the focus of the destruction center, an average of 44.5% of twigs were infected, whereas, at a distance of 70 to 130 m from the destruction center, where no trees had been killed, only a few nibble marks were found. In quadrat 165, at the focus of the destruction center, 39.3% of the twigs were infected; on the periphery of the destruction center, where only a few trees have been killed, 9% of the twigs were infected; in an adjoining stand of perfectly healthy trees, nibble marks were entirely absent (Table 2).

According to Ivanchenko (1957), in all plantations with dead trees, fruiting bodies of Ophiostoma are to be found in the S. intricatus nibble marks.

The connection between infection of the oak and supplementary feeding of S. intricatus is very nicely demonstrated by data on the number of attacks by beetles on trees having initial disease symptoms. These trees have, in addition to their normally colored leaves, a few branches bearing bright red or yellow leaves. According to Ivanchenko (1957), these branches show symptoms of vascular disease. Comparison between green and diseased branches shows that in all cases, the former have fewer nibble marks than do the latter (Table 3). This table

TABLE 5

Biochemical Composition of the Food of Scolytus intricatus Ratz. Larvae (oak phloem)

Date of taking sample	Material analyzed	% of water	% of dry weight			
			nitrogen	monosaccharides	dissaccharides	total sugars
12 VII	Trap-tree; newly felled	26.2	0.92	4.62	0.23	4.88
2 X	Trap-tree; rather dry	15.0	0.61	2.02	0.26	2.28
5 VII	Dry branches, infected by bark borers in 1955	10.0	1.0	0.83	0.20	1.038
8 VI	Tree-trunk; killed in 1955	15.6	0.60	0.76	0.04	0.80
31 V	Living branches (food of beetles)	43.0	1.8	2.54	0.03	2.84
6 VI	The same	40.5	—	3.35	0.31	3.66
3 VII	The same	36.2	1.1	3.57	1.28	4.85

TABLE 6

Physiological Condition of Scolytus intricatus Ratz. Imagines before and after Supplementary Feeding (laboratory experiments)

Experimental material	% water	% of dry weight		Respiratory coefficient
		nitrogen	fats	
Newly emerged beetles	58.6	8.2	14.3	0.7
Beetles having finished supplementary feeding	56.1	10.8	11.5	0.84

indicates that the degree of infection in a branch corresponds to the extent to which S. intricatus has fed on it. For example, in a tree situated in quadrat 170, a healthy branch had 20.7% of its twigs infected, a branch with initial disease symptoms (thinning out of leaves) 52.5%, and a diseased branch with bright red leaves 100%. A similar correlation was obtained in quadrat 186 (Table 3).

The connection between the degree of infestation of a tree by S. intricatus and the incidence of infection in it is also demonstrated by data on different parts of the crown. According to Ivanchenko (1957), diseased branches with brightly colores leaves first appear at the upper part of the crown. This is fully in accordance with the beetles' intensive colonization of the crown. Examination of four standard trees showed that the highest percentage of infected twigs is to be found in the upper part of the crown, and the lowest in its basal part (Table 4). Thus, there can be no doubt about the relationship between S. intricatus and the disease of the oaks.

Since the pathogen is carried to the tree chiefly by S. intricatus imagines, the present investigation was largely concentrated on details of their behavior and supplementary feeding.

An interesting feature of these xylophages is their ability to assimilate poorly digested lignin and to accumulate reserve materials, developing as they do on substrata deficient in nutritive matter. The lignin consists chiefly of carbohydrates—the slightly soluble cellulose (40 to 62%) and more readily soluble hemicellulose (16%). Living wood also contains reducing sugars, starch and proteins; the quantity of these substances varies according to the species, condition and part of the tree, and it determines the nutritive value of the xylophages' food (Deschamps, 1953).

Becker (1942, 1944a, 1944b, 1944c) concludes that the quantity of nutritive material present in the wood influences the speed of growth, weight, and feeding rate of insects kept under experimental conditions. The quantity of wood destroyed is inversely proportional to its nutritive value. In this author's opinion, the factor limiting growth in many species of xylophages is the quantity of nitrogenous substances in the tree. Addition of nitrogenous substances accelerated the development of all species investigated, and diminished the quantity of wood destroyed. The effect of sugars is highly specific. Addition of identical sugars may produce an acceleration of development in some species and a retardation in others. Becker has shown that nonuniform colonization of different parts of a tree by xylophages, and differing rates of development in these insects depend upon nonuniform biochemical composition of the substrate. Proteinaceous material is the most nutritious; heartwood is scarcely damaged at all by insects, because of its lack of protein. Analogous results have been obtained by various authors (Schuch, 1936) for the longicorn Hylotrupes bajalus L. and for Anobium pertinax L.

It is known that S. intricatus infects weakened trees, which are soon killed by the harmful activities of the larvae. Because of this, there are important differences in feeding habits between younger and older larvae of this species.

The food of younger larvae is more nutritious than that of older larvae.

As can be seen from Table 5, the felled trees which we used as traps incurred a loss, not only of water, but also of nutritive substances (sugars and proteins), in the course of their desiccation. Sugars were particularly subject to decomposition: after two and a half months (from July 12 to October 2) the total quantity of sugars was halved; the monosaccharides were the most rapidly decomposed. In winter, loss of nutritive materials occurs still more rapidly. Phloem from the trunk of a dead tree, which had been infected by S. intricatus in 1955, yielded only 0.8% sugar and 0.6% nitrogen when analyzed in the spring of 1956. In the same way, a big loss of nutritive substances was revealed in branches infected by the beetles in the summer of 1955 and killed as a result of their activity (Table 5).

Many xylophages compensate for nitrogen deficiency by feeding on fungi colonizing the wood. They are the longicorns, the urocerids, and bark borers of the genus Xyleborus (Becker, 1944c; Deschamps, 1953; Shoven, 1953), which have ambrosial fungi in their tunnellings. Development of such insects is quite impossible in the absence of the fungi. However, the presence of the fungi is not essential for S. intricatus. According to Ivanchenko (1957), only fungi of the genus Ophiostoma develop in the larval tunnels of this species, and only 25 to 30% of the tunnels are infected. It is therefore, easy to understand the need of S. intricatus imagines to compensate for food deficiencies during their period of supplementary feeding.

Comparison of the biochemical composition of dead and dying branches in which larvae are feeding with that of living twigs (the food source of the imagines), shows that the live twigs are richer in nutritive substances – in nitrogen and especially in sugars. In addition, the living tissues contain considerably more water (Table 5). When the beetles change over to more nutritious food, a number of changes in their physiological condition take place. During their period of supplementary feeding, the nitrogen supply is increased and some of their fat is expended. Important changes also occur in their respiratory metabolism. On emerging, the beetles, like all nonfeeding insects, have a fat-exchange (RC * = 0.7 to 0.72); when their development is complete, respiration is at the expense of protein (RC = 0.82 to 0.84) (Table 6).

The ovaries mature during the period of supplementary feeding. However, the eggs are not ready for laying until the beetles have copulated; copulation takes place in the tunnel constructed by the female.

TABLE 7

Degree of Infestation of Oaks by Scolytus intricatus Ratz. Imagines, depending on the Proximity of an Infection Source

No. of quadrat	No. of tree	Locality of sample	Nature of tree	No. of twigs examined	% of twigs infected
166	I ?	Center with many trees killed in preceding years, and with dead-crowned trees	Healthy tree at focus of destruction center, surrounded by dead trees	250	7.2
166	II	The same	Tree with dead crown, surrounded by dying trees	450	9.5
166	III	The same	Tree in destruction center, surrounded by healthy trees	230	0
166	IV	The same	The same	220	0
165	I	Small center with trees killed in previous year	Tree with dead crown, surrounded by dead trees	350	12
165	II	The same	The same	400	24
165	III	The same	Tree in destruction center; adjoins healthy trees	400	0
165	IV	The same	The same	400	0

*Respiratory coefficient.

These observations confirm the necessity of supplementary feeding for S. intricatus imagines and reemphasize their role as vectors of vascular disease. Observations on the behavior of S. intricatus imagines are of great practical importance in this connection, since the spread of destruction centers is wholly dependent upon the movements and flight range of the vectors. A study of their flight range can form the basis of measures aimed at restricting the spread of destruction centers.

According to the literature, the flight range of the closely related species, S. multistriatus, is not great. Thus, according to Wallace (1939), imagines of this bark borer do not fly further than 30 ft. In this author's opinion, wind plays a major role in the beetles' flight. However, the maximum range does not exceed 400 m. Other authors (Wolfenbarger, Buchmann, 1939; Wolfenbarger, Jones 1939; Wolfenbarger, Jones, 1943) also calculate that supplementary feeding of S. multistriatus always occurs at a short distance from the place of departure. Trees situated in the immediate vicinity of logs infected with S. multistriatus larvae had more nibble marks than did other trees lying at some distance from the logs. According to more accurate data (Collins, 1938, 1941), the flight range of S. multistriatus is a few hundred feet; it does not exceed 210 m (Collins, Parker, Dietrich, 1940). Felt (1940) quotes the opinions of other authors to the effect that S. multistriatus imagines can be carried by convection currents; however, in this author's view, only a very few beetles are transported in this way. Felt holds that, in general, S. multistriatus imagines are severely localized and move actively for only short distances.

Our own observations show that, in a developing destruction center, this species does not fly long distances. As can be seen from Table 2, only a few nibble marks are to be found in quadrat 170 at a distance of no more than 70 m from the destruction center; at a distance of 200 m, nibble marks are entirely absent. Restriction of the flight of S. intricatus in such destruction areas is confirmed by detailed studies conducted in other destruction centers situated in quadrats 165-166 (Table 7). In these quadrats, where full-scale destruction is the rule, there are a few minor centers, situated at a short distance from one another. These minor centers are made up of once healthy trees whose crowns were killed and which died in 1955 and preceding years. As can be seen from Table 7, even in one of these minor centers, the S. intricatus infection is not uniform. Nibble marks of this species are found only on trees surrounded by dead timber which supported young colonies of larvae during spring of the same year. Nibble marks of S. intricatus were not discovered on those trees not immediately adjacent to the healthy trees. Because of the restricted flight range of S. intricatus, destruction centers are more or less localized in the first years of their existence. However, the destruction spreads rapidly enough from the boundaries of the center.

As can be seen from Table 7, almost all the trees situated in the immediate vicinity of dying trees bear recent nibble marks of S. intricatus, and, consequently, are liable to infection.

A gradual change in the boundaries of the distribution center also took place. Thus, in the largest of the three existing centers, only sections of summer-oak were killed. In 1956, the initial sysmptoms of destruction —occasional dead trees and trees with dead crowns—appeared also in sections of winter-oak immediately adjoining the destruction center. It should be noted that the rate of growth of the centers depends largely on their distance apart. In old centers, i.e., where there has been almost complete destruction of the trees, it is observed that the beetles cover increasingly greater distances in flight. In these cases, there is a rapid migration of the destruction centers (Stark, 1925). In the Savala forestry, we were concerned with younger centers (two to three years old).

Formation of destruction centers can be prevented by well-timed removal of newly infected trees, and also by extermination of S. intricatus.

Systematic observations of the beetles' behavior showed that they were most active after maturation of the ovaries, during their flight to the egg-laying sites. Newly emerged beetles do not undertake long flights, but begin to feed immediately, establishing themselves in the twigs. During this period, flying beetles are hardly ever found in the forest; movement begins as soon as the feeding period is over.

It was stated that S. intricatus imagines readily settle on the wall of the insectarium situated in quadrat 149. We made use of this fact in compiling data on the flight dynamics of the beetles, by recording the number of specimens alighting on the enclosure wall every 30 min. In this way, the daily activity of the beetles and the seasonal duration of their flight period were established. Under natural conditions, the beetles began to emerge on June 1. By June 7 to 9, the majority had flown away from the logs kept in the insectarium. They did

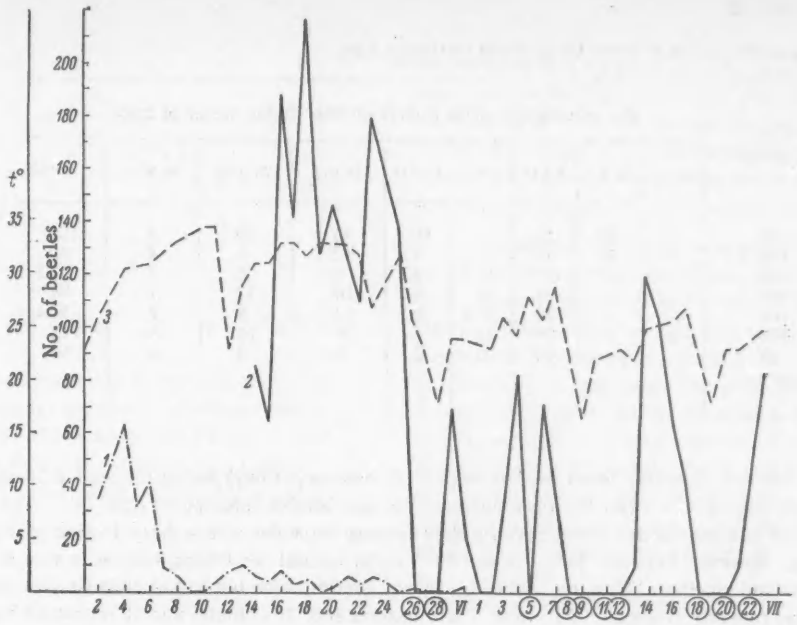

Fig. 1. Flight dynamics of Scolytus intricatus Ratz. in the Savala forestry (Voronezh region) during the summer of 1956. 1) Number of beetles emerging daily in the enclosure. 2) Number of beetles having finished feeding and arriving every 30 min on the enclosure walls. 3) Air-temperature (°C).

not begin to arrive on the outer walls of the insectarium until June 12. Dissection of beetles leaving the logs and of those settling on the outer walls of the insectarium showed a marked difference in internal condition between the two stages: in the former, the whole body cavity was occupied by fat, and the ovaries contained immature eggs; the latter had only a small quantity of fat, and their eggs were almost completely mature. The two groups of beetles also differed in their physiological state. Beetles leaving the insectarium have a fat-exchange (RC = 0.70 - 0.72), whereas a protein exchange (RC = 0.81 - 0.82) was recorded in specimens collected from the outer walls of the insectarium. In beetles of the first group, there is considerably less nitrogen than in those of the second group; beetles of the first group have more fat than do the latter. Comparison of these data with results of analyses of beetles reared under laboratory conditions (Table 6), shows that the physiological condition of beetles from the insectarium corresponds with that of newly emerged specimens. The condition of beetles arriving on the outer side of the enclosure wall corresponds with that of imagines which have already finished feeding (Table 6). This agrees with observations on the beetles' behavior. Those inside the insectarium begin at once to attack the twigs at their nodes, whereas those arriving on the outer walls of the insectarium establish themselves in tree trunks and thick boughs. At this time, the beetles begin to colonize the trap-trees, which up to now they have avoided. Thus, in 5 days (from June 12 to 19) 16 colonies were recorded from one linear meter of branch in quadrat 186; between June 19 and 24, 32 colonies were observed (Table 8).

The beetles are extremely active during the egg-laying period. They fly violently against the enclosure, repeatedly flying up and settling on the netting. They are also extremely active on the oak trunks. Here, they travel to and fro in search of suitable sites for egg laying. We deduced from our observations that the initial outbreak period in the formation of new destruction centers corresponds with the second half of the beetles' life history (the time of egg laying), when the beetles fly greater distances. The beetles cause little perceptible damage by laying eggs on weakened trees; however, when they feed on healthy trees in the following year, they carry the infection and so help to extend the destruction area.

Studies on the flight dynamics of S. intricatus showed that, in spite of the lengthy flight period (more than two months), departure of young beetles from logs in the insectarium takes place in a relatively short period. As can be seen from Fig. 1, the majority of beetles flew away during the first 10 days (40 to 60 beetles

TABLE 8

Infestation of Trap-Trees by Scolytus intricatus Ratz.

No. of quadrat	No. of colonies after 5 days on one linear meter of trunk								
	20 VI	25 VI	3 VII	8 VII	13 VII	18 VII	23 VII	28 VII	total
186	16	32	15	—	10	15	10	3	101
186	—	41	18	—	7	12	8	4	90
165	—	—	20	10	5.2	9.5	8	5	57.7
165	—	—	34	26	5.7	16	12	1	94
166	—	—	20	25.4	9.0	12	8	7	81.4
166	—	—	29	32	7	21	16	8	113
168	—	—	12	15	2	8	3	4	50
Winter oak									

per day). There were considerably fewer departures (4 to 10 beetles per day) during the second 10-day period; in the third 10-day period only a few beetles emerged. The last beetles departed on June 30. The beginning of the flight period in those beetles which have finished feeding coincides with a sharp decline in the number of beetles emerging. However, between June 10 and 20, under natural conditions, beetles in various growth stages are encountered together. Thus, on June 14, 75% of beetles collected had already finished feeding; the remaining 25% had recently emerged. On June 19, in quadrat 186, 16 colonies and 19 recent nibble marks were discovered in the same linear meter of felled branch. In the following records, very few newly emerged beetles were noted.

In 1956, the flight period of those beetles which had finished their supplementary feeding was longer than that of the emerging beetles. This must be put down to the effect of different weather conditions. Emergence of beetles occurred in very hot, dry weather. The flight in search of egg-laying sites coincided with heavy rainfall and a drop in temperature. At the time of the temperature fall, the number of flying beetles was greatly reduced; in wet weather, flying ceased altogether: this did not depend upon temperature. These facts explain the lengthy interruptions in the beetles' flight period at the end of June and between July 7 and 14, as well as the reduction in the number of colonies in the trap-trees (Table 8). In addition to temperature and rainfall, the beetles' flight is also limited by light intensity. This is a major factor determining the nature of the beetles' activity during the day. Observations have shown that when the S. intricatus imagines have finished feeding, they begin to fly during the second half of the day at about 4 to 5 P. M. However, they are most active at sunset, in the hours of dusk when the light strength is 3 to 5 meter-candles. The greatest number of individuals appears at this time. Later, when the gauge fails to register the light intensity, the number of flying beetles begins to decrease. They do not fly at all at daybreak, although the light intensity is the same as in the evening. Possibly their activity at this time is restricted by the somewhat lower temperature. All these characteristic features of behavior of S. intricatus imagines must be utilized in developing control measures.

Investigations in recent years, conducted over a wide area, have shown that extermination of the imaginal phase is the most suitable method of controlling wood-boring pests (Lozovoi, 1948; Livshits and Petrushova, 1949; Berdennikova, 1949, 1954; Cherepanov, 1952; Stark, 1954). In the case of S. multistriatus, the possibility of destroying the beetles during their period of supplementary feeding has been established.

In the USA, chemical control-measures against S. multistriatus were widely used for the first time in 1937 (Felt, 1940). However, encouraging results were obtained only when DDT and GBH were tried. The possibility of killing the beetles by spraying branches with an emulsion or water solution of DDT or GBH has now been established (Bromley, 1948, 1950; Pease, 1954, Matthysse et al., 1954). According to the last-mentioned authors, annual spraying of elm stands over a period of three years completely prevented the spread of Dutch elm disease in them. Dimand et al., (1949) state that emulsions of DDT are most convenient to apply, since DDT solutions can inflict burns. Plumb (1950) is also of this opinion.

Experience gained in the control of S. multistriatus can be applied to S. intricatus. However, if we take into account behavioral peculiarities of S. intricatus imagines at different stages of their development, we see

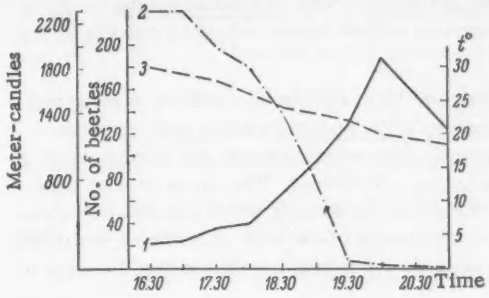

Fig. 2. Daily activity of Scolytus intricatus Ratz. imagines which have finished feeding. 1) Number of beetles arriving every 30 min on the walls of the enclosure. 2) Light intensity (in meter-candles). 3) Air temperature (°C).

that spraying will be more effective against beetles which have finished feeding; it is at this time that contact between insect and insecticide can be most easily effected. At the beginning of the flight, when the beetles rapidly burrow into the twigs, they are unlikely to come into contact with the poison.

The setting up of trap-trees provides another method of controlling the bark borers. The use of this method has been established in the case of S. multistriatus (Martin, 1936, 1946). We set up a small series of experiments, with the aim of elucidating the colonization of trap-trees by S. intricatus. The trap-trees, which were 15 years old, 7 to 10 cm in diameter and 4 to 5 m in length, were set up in four quadrats. The trees were examined every five days. The experiments indicated that trap-trees are intensively colonized by S. intricatus. At the end of two weeks, 57 to 113 colonies were recorded per linear meter of trunk (Table 8).

Typically, only the lower part of the trunk is colonized, the upper part being unaffected.

Colonization of trap-trees takes place as in the taller trees, but the number of beetles is lower. Thus, 50 colonies per linear meter of trunk were recorded after two weeks in sections of winter-oak (quadrat 166), where only a few S. intricatus nibble marks were to be found.

The greatest number of colonies was registered during the first days of flight. The reason for this does not depend, in our view, on the condition of the trap-tree, but on the total number of flying beetles: there were fewer of these at the end of July than during the first ten days of the month.

It must be taken into account that newly felled trees are scarcely colonized by S. intricatus. In quadrats 165 and 166, where the trees were set up on June 29, the first colonies were not recorded until July 8, i.e., 10 days later. This method of control certainly merits closer study.

One of the principal methods of controlling these insects is well-timed felling of newly colonized trees. However, such felling is only used in the Lipetsk estate when destruction reaches major proportions. It is not carried out in new destruction centers with small quantities of dead timber (quadrats 170, 179, 183). However, even in major centers, felling of dead trees proceeds slowly. Thus, in several quadrats (186, 188 and 189) no such felling has been carried out in recent years. Trees killed in 1953-1954 are still standing here. When feeling is used in such conditions, it is confined to old, dead timber; trees killed in the preceding fall and spring, which constitute the main infection source in the plantations, are left standing. Thus, felling as conducted here does not remove the most dangerous representatives of this group of pests from the plantation. For example, in quadrat 195, during the intensive felling of May, 1956, only a few branches which had been infected by S. intricatus in 1955 were found (tunnels with living larvae and pupae). Surveys carried out on July 14 in this quadrat showed that a large number of branches had recent colonies of S. intricatus: 30 to 50 colonies were counted per linear meter of branch. Moreover, about 75% of twigs on a felled tree of standard type bore S. intricatus nibble marks. Thus, as a result of incorrectly carried out felling in quadrat 195, large quantities of S. intricatus remained in the plantation. Chief cause of the great increase of this species and the resulting spread of disease in the Lipetsk estate was the incorrect and ill-timed felling of the oaks. Well-timed use of exterminatory and prophylactic measures against S. intricatus may prevent the spread of destruction.

SUMMARY

Extinction of large areas of oak woods in the forest-steppe and steppe zones of the European part of the USSR has taken place during recent years. The oaks were killed by a vascular disease caused by a pathogenic fungus Ophiostoma sp. Special investigation has been undertaken at the Savala forestry (Voronezh region of the RSFSR) with the purpose of finding the vector of this disease.

It has been established that among the wood and bark borers (Plagionotus detritus L., P. arcuatus L., Mesosa myops Dalm., Gasterocercus depressirostris L., Xiphydria prolongata Geoffr., Agrilus biguttatus F., A. angustulus Ill., A. hastulifer Rtzb., Scolytus intricatus Ratz.) occurring in these woods, only the latter is a vector of Ophiostoma.

The biology of S. intricatus is similar to that of S. multistriatus Marsham, the only difference being that the former is univoltine, whereas the latter is bivoltine. The females of S. intricatus emerge with immature ovaries and require supplementary feeding on slender twigs. Not only Ophiostoma-infested, but also perfectly healthy trees are attacked. It is by these adult beetles that the fungus is introduced. The larvae develop only on weakened trees and take no part whatever in the transfer of the disease (remaining within one tree throughout the larval phase). Accordingly, the main attention was drawn to the biology of the adult phase which was studied in detail, in particular the feeding habits and the behavior of beetles. It has been established that the range of flight does not exceed 100 meters.

The activity of beetles is restricted by the temperature and light-intensity limits.

The recommended control measures are the spraying of tree crowns with the emulsions or water solutions of DDT or GBH, trap-logs, and the felling of trees recently by Scolytus intricatus.

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THE BIOLOGY AND ECONOMIC IMPORTANCE OF TRICHOGRAMMA EMBRYOPHAGUM (HTG.) (HYMENOPTERA, TRICHOGRAMMATIDAE)

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The role of the forest trichogramma Trichogramma embryophagum (Htg.) in the reduction of its host populations and in the suppression of increases in many phytophages, living at the expense of arboreal plants, is widely known. Undoubtedly studies of the features of the biology and economic significance of this parasite, and also of establishing the possibility of its utilization in the forest, are of considerable interest.

1. Systematic position. The species was described first by Hartig [1838] as Encyrtus embryophagum from specimens reared from eggs of the pine lappet. This name is retained by Ratzeburg [1844]. Finally, the trichogramma obtained from eggs of forest insects was named Trichogramma piniperdae (Wolff [1915]); from eggs of the pine noctuid T. evanescens (Hase [1925]); from eggs of the nun moth, (Escherich [1931]), of the pine noctuid, (Schwerdtferger [1944]), of Acantholyda erythrocephala, (Nunberg [1946]) and of Acantholyda nemoralis; T. Pini (Meier [1940]) were obtained from eggs of the pine lappet.

According to Meier [1940], T. pini is distinguished from T. evanescens not only by coloration but also by the ratio of the length and width of the forewing and over-all body size, and according to Quednau [1956], T. embryophagum is distinguished from T. evanescens by the sizes of the setae on the last antennal segment of males and the length of the fringe of the forewing in both sexes; however, the latter feature, according to data on measurements taken, does not appear to be sufficiently reliable.

According to data in the works of Meier [1940] and Quednau [1956] and measurements taken by us on numerous specimens reared from eggs of the pine lappet and the pine looper, separation of the species should be based on the following morphological features:

	T. embryophagum	T. evanescens Westw.
Over-all body size	0.5-0.9 mm	0.29-0.35 mm
Coloration	Pale yellow *	Dark brown
Length-width ratio of the forewing	1.6-1.7	1.8-2.0
Setae on the last antennal segment of males.	Approximately twice as long as the width of the antennal segment.	Approximately 3 times as long as the width of the antennal segment.

The forest trichogramma is distinguished not only by morphological differences, but also for the most part, on an ecological basis, by specific host preferences, relationships with forest biotopes, high fecundity, preeminent predominance of females, fewer requirements of temperature conditions, a faster horizontal and vertical dispersal.

2. Hosts. The species is associated mainly with forest phytophages, the eggs of which are laid exposed on needles, leaves, trunks or branches. The number of host species, apparently, is quite considerable, but to date the following species are known:

*With development under temperatures below 17°C there appears a brown pigmentation on the mesosternum and belly.

A. Hymenoptera: Pamphilidae (Lydidae)—1) Acantholyda nemoralis G. G. Thoms. (Scheidter, 1926; Nunberg, 1946; Klomp, 1956), 2) Acantholyda erythrocephala Chr. (Schwerdtferger, 1944).

B. Lepidoptera: Lasiocampidae—3) Dendrolimus pini (L.) (Ryvkin, 1940; Meier, 1940; Smirnov, 1948), 4) Dendrolimus sibiricus Tschv.; Geometridae—5) Bupalus piniarius L. (Escherich, 1931; Zwölfer, 1956), 6) Hematurga atomaria L., 7) Macaria liturata Cl., 8) Larentia variata var. obeliscata Hb., 9) Gnophia (Atolmis) rubricollis, 10) Ellopia prosapiaria L. (Klomp, 1956); Noctuidae—11) Panolis flammea Schiff. (Eidmann, 1934); Sphingidae—12) Hyloicus pinastri L., 13) Sphinx ligustri L., 14) Smerinthus populi L.; Tortricidae—15)Evetria resinella L., 16) Evetria buoliana Schiff. (from observations of L. T. Krusheva); Orgyidae—17) Lymantria monacha L. (Hase, 1925; Vasil'ev, 1913), 18) Dasychira pudibunda L., 19) Orgyia antigua L., 20) Euproctis chrysorrhoea L. (Howard a. Fiske, 1911; Fankgenel', 1956); Notodonidae—21)Phalera bucephala L., 22) Pygaera pigra Hufn. (Smirnov, 1948), 23) Pygaera anachoreta F.

3. Fecundity and sex ratio. The forest trichogramma, reared from eggs of the pine lappet and other large eggs of forest insects, is distinguished by the greatest fecundity and a large predominance of females in comparison to other species of this genus. In our laboratory it is cultured on eggs of its principal host the pine lappet, and partially on the pine hawk moth and pine looper. Its fecundity does not decrease as a consequence of laboratory rearing.

The average fecundity of the species was determined by us in the following way. Into separate test tubes were placed 1 to 10 eggs of the pine lappet and a single mated trichogramma female. After 30 days a count was made of emerged individuals of the new generation (Table 1).

TABLE 1

Mean Fecundity of Single Females of Trichogramma embryophagum (Htg.)

No.	No. of eggs in test tube	Results of infection							
		No. of eggs			No. of trichogramma individuals emerged				
		from which emerged		without exit holes (punctured)	♀♀	♂♂		total	the average from a single pine lappet egg
		trichogramma individ	caterpillars			wing-ed	wing-less		
1	1	1	—	—	40	—	—	40	40
2	2	2	—	—	130	3	—	133	66
3	3	3	—	—	125	2	—	127	42
4	4	4	—	—	175	5	—	180	45
5	5	4	—	1	150	8	1	159	40
6	6	6	—	—	195	10	—	205	34
7	7	5	1	1	125	9	1	135	27
8	8	6	—	2	155	5	—	160	27
9	9	6	—	3	152	5	1	158	26
10	10	7	1	2	160	3	2	165	24
Total	55	44	2	9	1407	50	5	1462	—
In %	100%	80%	3.6%	16.4%	96.3%	3.4%	0.3%	100%	—
Mean fecundity of a single female								146.2	33

As the data in this table indicate, the fecundity of the forest trichogramma averages exactly 146. In most individuals it exceeds 150, in separate cases reaching 180 and 205. According to data of investigations in 1958, the fecundity of some individuals of this egg eater reaches 340 eggs. The sex ratio of the forest trichogramma is extremely variable, but is always characterized by a significant predominance of females. Fecundity of other species of this genus is much lower: T. evanescens Westw. lays an average of 13-20 eggs (Meier [1941]), T. pallida Meyer 33-37 (Telenga [1956]), T. japonicum in China 15-61 (Hwu Jung-sei [1956]), upon which females constitute just 50.7-63% of T. evanescens populations.

Data from Table 1 also show that from one egg of the pine lappet an average of 33 forest trichogramma emerge, with a range of 24 to 66. The more eggs that are infected by a single female, the fewer individuals of progeny emerge from a single host egg. When a trichogramma infects two lappet eggs a mean of 66 individuals emerge from a single lappet egg, with an infection of 3-4 eggs 40-50 individuals, with an infection of 5-6 eggs 26-34, and with an infection of 7 eggs 24.

Characteristically each female trichogramma infects and punctures, partly for feeding purposes, up to 10 pine lappet eggs. Only in two cases did a caterpillar emerge from a lappet egg. Puncturing of separate eggs for feeding purposes was noted only in cases where 5 and more lappet eggs were placed in a test tube. Under conditions of massive increase of the pine lappet in the forest, when host eggs are present in large numbers, the trichogramma apparently infects not less than 6 eggs, since the average number of its individuals in one host egg in the forest also equals 33.

4. Winter and summer diapause. We determined that in the winter of 1955/56, in areas of mass breeding of the pine lappet, the forest trichogramma overwintered in the larval stage in eggs of the nun moth. Emergence of adult parasites did not occur until the spring of 1956. In these places no caterpillars emerged in 1956 from nun moth eggs laid in July 1955. Apparently they were all infected with the egg eater. In the places mentioned, in the summer of 1955, a release was conducted of trichogramma reared in the same year on pine lappet eggs in the laboratory.

Overwintering of the forest trichogramma in eggs of the host has been observed also by some other authors. Klomp states that in Holland it overwinters in eggs of Thera firmata Hb., Th. obeliscata Hb., Acantholyda nemoralis Thoms.

The overwintering of trichogramma in host eggs is likewise noted for other species of this genus. A Chinese author (Hwu Yungsei [1956]) states that in China T. japonicum Ashmead overwinters in the host egg in the pupal stage and does not emerge until April. Clausen [1940] maintains that in the latitude of Tokyo the trichogramma overwinters in all stages of development, but in the more northernly places only in the mature larval stage. Lucchese [1941] found that the trichogramma overwinters in eggs of Acroclita naevana Hb. with emergences of adult insects in April-May. According to the data of Kryger [1920] the trichograma overwintered in eggs of the grass lappet Gastropacha potatoria L. on willow in the larval stage and only in spring did the adults emerge from infected eggs (34 individuals from two host eggs, of which 32 were females). As is well known, eggs of the above-named lappet usually do not overwinter and the caterpillars hatch from them in August, but the trichogramma, usually completing its development in a short period, remains in diapause until April of the following year. In the present case not only was a winter diapause observed for the trichogramma but also a summer diapause.

Mayer [1955] states that eggs of some hosts, may, with their own physical-chemical properties, induce diapause in trichogramma. To such he referred, in part, the pine noctuid, Acantholyda nemoralis Thoms. and Cacoecia rosana L. An exception may be taken to Mayer as trichogramma does not undergo diapause in all the eggs of the same host. A case is known when trichogramma undergoes diapause in some parts of the host egg, but in other parts its development is completed in its usual time, viz., in the summertime it emerges in 12-20 days. Scheidter [1926] for example, presents the following observations. In the forestry of Artsburg in 1921, 98% of the eggs of Acantholyda nemoralis Thoms. were infected by trichogramma, which was responsible for the total suppression of the infestation of the mentioned pest. (The chorion of this species of sawfly is not thick and the dark coloration which it received when the prepupal stage of the trichogramma is reached is very noticeable; for this reason eggs infected by trichogramma are easily distinguished from uninfected ones). However, in the same year trichogramma did not emerge from all of the sawfly eggs; from most of the eggs trichogramma did not emerge until spring of the following year. Most likely, in the present case there is occurring an adaptation of the parasite to the host, manifesting a tendency to synchronize with it, but a few parasite individuals which emerge in the year of infection may ensure their development, in small numbers, on other hosts.

Klomp [1956] determined that host eggs, which are infected by trichogramma during the second half of September, undergo diapause even with warm weather and produce adults only in April-May of the following year. This is observed in all species and forms of trichogramma.

According to the opinion of Telenga [1954] the biological significance of autumnal diapause in trichogramma consists, mainly, of protection from the consequences of temporary temperature rises during the autumnal period: "If the larvae of trichogramma should not enter the state of diapause, then the rises in temperature during

TABLE 2

Duration of Development in Trichogramma embryophagum (Htg.) in Eggs of Dendrolimus pini (L.) depending on Temperature and Relative Atmospheric Humidity

Data		Air temperature (in °C)			Mean relative atmospheric humidity, %	No. of eggs in test	Duration of development in trichogramma (in days)
placement of eggs into virarium	emergence of trichogramma	mean	minimum	maximum			
7 VII 55	16 VII 55	27.1	24.5	29.5	64	850	9
6 VIII 55	16 VIII 55	24.1	22.5	26.0	70	200	10
8 VIII 55	18 VIII 55	24.3	22.5	28	68	200	10
30 VI 55	10 VI 55	25.5	23	29.5	67	436	10
2 XI 55	13 IX 55	24.8	20.5	28	63	300	11
12 VII 55	23 VII 55	25.9	23	28	63	200	11
1 VIII 55	12 VIII 55	25.3	23	28.5	69	200	11
22 VI 55	4 VII 55	23.5	20	26	68	300	12
18 VIII 55	31 VIII 55	26.8	24	29.5	66	200	13
18 VI 55	2 VII 55	22.8	19.5	26	68	50	14
18 VII 55	23 VII 55	23.6	21	27	68	1000	14
24 VIII 54	12 IX 54	21.8	16	29	75	200	19
20 IX 54	9 X 54	14.2	9.5	19.5	76	50	20
6 XI 54	26 XI 54	17.5	15	20.5	63	100	20
16 IX 54	7 X 54	15.4	10	22.5	75	200	21
13 V 54	5 X 54	16.8	11	24.5	75	100	22
22 X 54	15 XI 54	18.1	15	21.5	65	50	22
26 VIII 54	17 IX 54	21.4	16	29	75	100	22
1 IX 54	23 IX 54	20.8	15.5	29	75	100	22
25 II 55	19 III 55	19.2	16.5	22.5	52	200	22
11 XI 54	4 X 54	17.5	11	24.5	75	200	23
27 IV 55	20 V 55	19.3	15	24	64	100	23
17 X 54	11 XI 54	18.2	15	21.5	65	50	24
23 IV 54	17 V 54	17.5	9.5	23.5	76	50	24
28 V 55	23 VI 55	19.6	15	23.5	67	100	26
12 IV 55	10 V 55	17.9	13	21.5	60	100	28
28 III 55	27 IV 55	18.5	13	24	52	100	30
9 II 55	12 III 55	18.2	15	22.5	54	150	31

the autumnal period might lead to the appearance of the adult stage and result in its death, since insect eggs that are necessary for infection are absent during this time" (Telenga [1954,51]).

Under certain conditions of temperature, moisture and light it is possible to induce diapause in trichogramma at any time of year. Skripchinskii [1927] fixes 9°C and 65% relative atmospheric humidity for diapause in T. barathrae, Zorin [1927] for T. evanescens Westw.—10-11°C, and Telenga [1954] for the same species 10°C, Eidmann [1934] for the forest trichogramma 8°C. Not one of the authors named considered the light factor. The possibility is not excluded that with a short day diapause might be induced under somewhat higher temperatures.

The capacity of trichogramma to enter autumnal diapause has significance in laboratory rearings of this parasite. Telenga [1954], in connection with this, proposed placing sitotroga eggs infected with trichogramma into test tubes and moving them outside of the laboratory as soon as the temperature is low enough.

There is much data on the mortality of trichogramma larvae during the winter period. We found significant mortality of trichogramma in the severe winter of 1939/40 in one of the mass breeding areas of the pine lappet in the Terekhovskii district. In the autumn of 1939, in the place named, there were very many eggs eaters, both telenomus (Telenomus verticillatus Kieff.) and trichogramma. Eggs of the pine lappet taken into the forest for test purposes in May and June of 1940 were infected predominantly with telenomus but not with trichogramma. Apparently the latter at that time was in the preimaginal stage of development in eggs of other hosts or was completely destroyed following the severe frosts during the winter of 1939/40.

5. Duration of development, number of generations and alternate hosts. The duration of development in the forest trichogramma is found to depend directly on temperature and atmospheric humidity and coincides approximately with the developmental terms of other trichogramma species, determined by other authors (Meier [1941]; Telenga [1956]).

The duration of development in the forest trichogramma under different conditions of temperature and humidity is presented in Table 2.

This table indicates that the duration of development in the forest trichogramma is 9-20 days. Thus, during the course of the vegetative period in the central regions of the European part of USSR, it may have up to 5-7 generations depending on weather conditions and presence of host eggs. On the pine lappet, whose flight usually lasts up to 7 and more weeks, the forest trichogramma may produce up to three generations. This explains the significantly great infection by the named parasite of eggs laid at later times in comparison with infection of early eggs. In connection with this the increase in effectiveness of trichogramma in the forest should be proportionate, to the increase, at the beginning of its flight, in the eggs of the pest against which it is employed.

Escherich [1942] reports that in 1936 he observed the gradual increase in the infection of the pine looper by trichogramma from 5 to 70%. This was explained by the fact that the flight of the pine looper was extended in that year and the weather conditions favored the development of trichogramma within short terms. Zwölfer [1956] presents the following data. In central Franconia there was massed not only the pine looper, but also the pine noctuid. In spring trichogramma parasitized the eggs of the pine noctuid in one or two generations and at the end of May transferred to the eggs of the pine looper. This shows that a change of hosts by the forest trichogramma in the course of its flight has great significance.

Alternation of hosts by the forest trichogramma through the duration of the vegetative period is observed even under the conditions of pure pine stands. In regions of massive increases of the pine lappet in the Belorussian and Ukrainian forest area it has 5-6 generations in the course of the summer. The first generation of this parasite is smallest in number. The numbers of hosts, in whose eggs trichogramma overwinters in the larval stage, are usually insignificant in such cases. In addition, the overwintering trichogramma in some years suffers from winter temperature minimums. Trichogramma emerges from overwintering host eggs during the first half of May. At this time it finds only the latest eggs of the pine noctuid and partially eggs of some other species laying in May.

The alternation of hosts by the forest trichogramma in regions of massive increases of the pine lappet in the forest area may be presented in the following form (Table 3).

TABLE 3

Generation	Date intervals	Hosts
I	V	Pine noctuid (rarely), Acantholyda nemoralis Thoms., Ellopia prosapiaria L., Thera obeliscata Hb.
II	VI (1-2)	Pine looper, heather looper, Semiothisa liturata Cl., Evetria resinella L.
III	VI (3) - VII (1)	Pine sphinx, Evetria buoliana Schiff., pine lappet (first eggs).
IV	VII (1-3)	Pine lappet, pine sphinx, nun moth (remain in diapause).
V	XIII (1-2)	Pine lappet, heather looper.
VI	VIII (3) - IX	Thera firmata Hb., Th. obeliscata Hb. (remain in diapause).

In pine stands mixed with deciduous species conditions for breeding of the forest trichogramma are still more favorable in connection with the presence, in such plantations, of large numbers of its hosts. Steiner (Steiner, 1931])presents data on the infection of pine looper eggs with parasites in different stand compositions. In a pure pine stand infection equaled 17.0%, in a pine stand with young spruce 37.62%, in a pine stand with a lower story of beech, 42.2%. Approximately the same picture is presented by Yana for Japan in relation to the infection of pine lappet eggs with egg eaters in pure pine and mixed stands.

Along with this there is also a great deal of data on heavy infections by trichogramma of pine pest eggs in pure pine stands. In the forest of Rittel in Germany in 1914, 60% of pine noctuid eggs were infected by trichogramma (Wolff [1915]) also 60% of pine looper eggs in Oberpfaltze in 1896 (Eckstein [1923]),in other regions of

Germany to 70% (Escherich [1942]), eggs of Acantholyda nemoralis Thoms. in 1921 in the forestry of Artsberg to 98% (Scheidter [1926]) and others. However, the heavy infection by trichogramma of the above-named sawfly and also the pine noctuid is associated not so much with the alternation of hosts by this parasite as with its diapause.

6. Number of trichogramma individuals emerging from a single host egg. The forest trichogramma is adapted to infecting large, openly situated insect eggs.

Directly dependent on size of host egg is the size and number of trichogramma individuals emerging, their fecundity and sex ratio. The larger the host egg, and the more females there are in the parasite population, the higher is their fecundity, and the larger is the size and number of individuals emerging from a single egg. From each infected pine noctuid egg an average of 8 trichogramma individuals emerge (Escherich [1931]), from each egg of Acantholyda nemoralis Thoms. 2-24 (Scheidter [1926]), from each pine lappet egg, 33. In laboratory rearings overinfection is sometimes observed (with 80-90 parasite individuals in a single pine lappet egg) which leads to diminished size of individuals and a lowering of their fecundity. In connection with this, lappet eggs to be infected by trichogramma are placed in a vivarium for only 1 day and in quantities that allow about 5-6 hosts eggs for each trichogramma female.

7. Horizontal and vertical dispersal. The forest trichogramma possesses the ability to disperse in both vertical and horizontal directions. At emergence it rushes upward and settles in all parts of the tree crown, where it first infects host eggs in the most illuminated places. This is supported by our data on counts of pine lappet eggs infected by parasites in two areas (Ryvkin [1950]).

Thus in both areas eggs which were laid in the middle and upper parts of the crown were most heavily infected by trichogramma. Infection by trichogramma of pine lappet eggs on border trees in the first area was as follows: in lower parts of the crown 12.5%, in the middle 29.2%, in the upper 12.0%. On trees within the stand in the same area, correspondingly: 1.4, 2.1, 2.5%; in the second area: on border trees 0.6, 1.9, 1.9%, on trees within the stand 1.9, 1.9, 1.8%.

Thus in all cases infection of pine lappet eggs by trichogramma was higher in the middle and upper parts of the crown than in the lower parts.

The dispersal of this species of trichogramma in a horizontal direction may be judged by the following data. In 1955, 4 weeks after its release in a forest it was found at distances of 120-130 m from the site of release.

8. Laboratory rearings of the forest trichogramma. Laboratory rearings of the forest trichogramma are conducted on eggs of the pine lappet or its other hosts. Eggs of the pine lappet, as we [1950] have already stated may be obtained at any time of year.

A very important peculiarity of the forest trichogramma is the absence of individual immunity of host eggs in relation to their infection. Eggs of its known hosts, particularly of the pine lappet, even in the most vigorous populations (in years of their build-up), all without exception are infected in the vivarium by this parasite. In this way the forest trichogramma is distinguished from some other egg eaters.

Supplementary feeding of the forest trichogramma with honey or, in the last resort, dissolved sugar increases its fecundity. The optimum rearing temperature (under which oviposition is maximal) is 16-20°C. For T.evanescens Westw. it is 25-29.7°C (Schulze [1926]).

9. Experiments in utilization of trichogramma in controlling the pine lappet. Experiments on releases of the forest trichogramma for controlling the pine lappet were conducted in 1955 in pine stands of type G, kv. 82 using forestry light traps in plots of about 18 hectares (in adjacent sections of the same block other means of controlling the pine lappet were employed).

The following inventory describes the stands of the western plots of type G: 10 c, 25 years, mean diameter 12 cm, mean height 18 m, stand density index 0.7, site class III, single 50-year pines, mean diameter 40 cm, mean height 15 m. The following inventory describes the eastern parts of the stands in the plot of type G; 10 c, 23-25 years, mean diameter 18 cm, mean height 15 m, stand density index 0.8, site class II. The mean infestation of a single tree during the flight period of the pine lappet in July- August of 1955 was 4-8 egg clutches.

TABLE 4

Infection of Pine Lappet Eggs by Parasites in Places of Trichogramma Releases according to a Survey of September 11-12, 1955

Block	No. of eggs examined	Of which (in %)			
		with evidence of larval hatch	infected with parasites		with dead larvae or dehydrated
			with telemonus	with trichogramma	
Western	2807	29.8	28.2	39.8	2.2
Eastern	4411	45.0	18.3	32.6	4.1
Total	7218	37.4	23.2	36.2	3.2

A cold late spring in 1955 somewhat retarded the developmental periods of the pine lappet in the regions of Poles'ya. On June 27 only 6% of the caterpillars pupated and on the first of July 30%. Flight of the lappet was observed from July 1 to August 27 with the peak August 3-6 (in ordinary years, flight of the pine lappet is completed during the first part of August).

In the western parts of the block, releases of trichogramma took place from July 9 to August 29, i.e., during the first half of flight and oviposition period of the pine lappet, and in the eastern parts of the block, releases of trichogramma took place from July 30 to August 15. In 1956 in the same block a supplementary release of trichogramma was conducted.

A survey of infection of pine lappet eggs by parasites at sites of trichogramma releases was conducted September 11-12, 1955 (Table 4).

The data in this table indicate that in places of trichogramma releases, only 37.4% of the larvae hatched from eggs of the pine lappet. The average infection by telenomus was 23.2%, which conforms to the usual level of infection of the lappet eggs by this parasite as observed in years of the eruptive stage of massive increase in areas of the Poles'ya zone (Ryvkin [1950]).

Infecton of lappet eggs with trichogramma reached 36.2%, and in one of the blocks 39.8%, while the usual infection of the lappet eggs with the parasite is 2%. Nevertheless, the average infestation of a tree by caterpillars of the pine lappet in the autumn of 1955 and in the first half of summer in 1956 was still very significant. But in the course of May, June and July, 1956, caterpillars of the pine lappet and its prepupae were infected with tachinids and sarcophagids. Presence in the area of parasites on caterpillars and prepupae of the pine lappet concentrated toward a decrease in the numbers of caterpillars and prepupae. Following this the flight of the pine lappet in 1956 was insignificant. Single egg clutches of the lappet in 1956 were intensively infected with both telenomus and trichogramma (Table 5). In the western parts of the block no supplementary work was conducted on control of the lappet (the eastern part of the plot was concerned in some degree with other methods conducted in adjacent blocks). Nevertheless a survey of the population of pine lappet caterpillars overwintering in the forest floor confirms that the numbers of the latter in the whole block were entirely insignificant (Table 6).

DISCUSSION

1. The forest trichogramma Trichogramma embryophagum (Htg.) is linked with forest biotopes and parasitizes openly situated eggs of many species living in the larval stage at the expense of arboreal plants, among them massive forest pests, the pine lappet (Dendrolimus pini L.), the pine looper (Bupalus piniarius L.), the pine noctuid (Panolis flammea Schiff.), and the pine sawfly Acantholyda nemoralis Thoms.

TABLE 5

Infection of Pine Lappet Eggs with Parasites in Places of Trichogramma Releases according to the Survey of August 31, 1956

Block	No. of eggs examined	With evidence of larval hatch	Of which (in %)				
			infected with parasites			barren	with dead caterpillars
			with telenomus	with trichogramma	pachyneoronus		
Western	200	12.0	36.5	46.0	2.0	1.5	2.0
Eastern	200	15.5	56.0	25.5	0.5	1.5	1.0
Total	400	13.7	46.0	36.0	1.3	1.5	1.5

2. The forest trichogramma, which develops in large eggs of dendrophilous insects is distinguished from other species and forms of the genus by a high fecundity and maximum predominance of females. The average fecundity of a single forest trichogramma female is 146 eggs, with a maximum of 205 (Table 1). In 1958,the mean duration of development of a single generation in the summertime was 9-20 days (Table 2).

TABLE 6

Populations in the Forest Floor of Primary Pests in Places of Trichogramma Releases according to the Survey of October 31-November 4, 1956

Block	No. of sections in 3.14 m^2 examined	Population per m^2 of forest floor			
		with caterpillars of the pine lappet			with pupae of the pine hawk moth
		young	old	total	
Western	21	1.4	0.7	2.1	0.01
Eastern	19	0.2	0.9	1.1	0.05
Total	40	0.8	0.8	1.6	0.03

3. Existence of the forest trichogramma in the forest during the course of the vegetative period is supported by a successive alternation of hosts, which is secured also in the lean biocoenoses of pure pine stands. With a sufficient quantity of host eggs the first generation of the forest trichogramma rapidly increases in number. During a massive increase of any one of its hosts and with an extension of its flight, the forest trichogramma breeds for several generations on its eggs, which conditions a sharp rise in infection of eggs that are laid in the last period of its flight and oviposition.

4. A critical period in the life of the forest trichogramma is overwintering. Trichogramma overwinters in the larval stage in eggs of but a few hosts which overwinter in the egg stage. In some cases summer diapause was observed in trichogramma in host eggs, which should be regarded as an adaptation toward attainment of synchronism with the host.

5. In areas of mass increase of the pine lappet with a usual number of other hosts of the forest trichogramma, infection of lappet eggs is not high (2-3%). Eggs of the pine lappet, just as those of other hosts, have no individual immunity to the forest trichogramma even in years of growth in their numbers, when the host populations are vigorous. Infection of host eggs with trichogramma is limited only by their numbers. Supplementary introduction of the forest trichogramma into areas with the pine lappet and other species at the beginning of flight and oviposition produces a noticeable effect (Table 3).

6. Laboratory rearings of the forest trichogramma should be conducted on eggs of the pine lappet or other hosts.

7. With overinfection trichogramma individuals diminish in size and their fecundity decreases. Prevention of overinfection is attained by leaving the lappet eggs in the vivarium for the duration of only one day, and by allowing about 6-7 host eggs for each trichogramma female. With the infection of 2 lappet eggs by a single female trichogramma an average of 66 parasite individuals emerge from one host egg, with the infection of 3-4 eggs 40-45, with the infection of 6 eggs 26-34, with the infection of 7, 24 individuals. Directly in the forest an average of 33 individuals emerge from one pine lappet egg. Thus laboratory rearings should be aimed at keeping the number of parasite individuals emerging from one host egg close to this number.

SUMMARY

Trichogramma embryophagum (Htg.), a polyphagous egg parasite, is associated with forest biotopes. Eggs are deposited into the large eggs of many dendrophilous insect species, whose larvae are defoliators of trees and shrubs, including such destructive forest pests as the moths Dendrolimus pini L., Bupalus piniarius L., Panolis flammea Schiff. and the sawfly Acantholyda nemoralis Thoms.

Among the species of the genus trichogramma T. embryophagum is dintinguished for its outstanding fecundity (the average and the maximum observed fecundity being about 146 and 205 eggs per female respectively, see Table 1)* and the overwhelming prevalence of females. The average duration of the life cycle in summertime varies from 9 to 20 days, depending mainly on the air temperature and the air humidity (see Table 2). The persistence of the active phases of T. embryophagum throughout the vegetative period is provided for by the succession of hosts, being possible even in the poor biocoenoses of pure pine stands. If the eggs of the hosts providing the first generations of the parasite are abundant, the latter rapidly increases in numbers. In the time of an outbreak of any of the host species, especially of those characterized by a protracted period of flight and oviposition, several successive generations of the parasite develop on the eggs of each generation of the host the percent infestation rapidly increasing toward the end of the oviposition period.

Hibernation is the critical period in the annual cycle of T. embryophagum. The trichogrammatid overwinters as larva in the eggs of but a few host species hibernating as egg. Under certain conditions a summer diapause is observed in the development of T. embryophagum inside the host's eggs that should be regarded presumbly as an adaptation, viz.,the synchronization with the host's life cycle.

In the areas of mass breeding of D. pini (the numbers of other hosts being usual) the average percent-infestation of the eggs of D. pini in the middle of the oviposition period is rather low (2-3%). Neither the eggs of D. pini, nor those of any other host species have individual immunity to T. embryophagum even in the years of rapid increase in numbers of the host species, when the vigor of the host populations is at its highest. Therefore, the proportion of infested eggs depends entirely on the relative densities of the host and the parasite. Releases of T. embryophagum in the areas of mass breeding of D. pini and other host species in the beginning of flight and oviposition have proved to be very efficient. T. embryophagum can be bred in the laboratory on the eggs of any host attacked in nature. Overinfestation results in the dwarfing and low fecundity of emerging parasites. It can be avoided by leaving the host's eggs in contact with the parasite for no longer than one day and by supplying a sufficient number of host's eggs per one female of T. embryophagum. Thus, the number of eggs of D. pini per one female of Trichogramma should not be less than 6 or 7. The average number of parasites emerging per one egg varies inversely to the number of host's eggs per one female T. embryophagum. Thus, 66, 40-45, 26-34 and 24 parasites respectively emerge from 1, 3-4, 6 and 7 eggs of D. pini infested by one female. The average number of parasites emerging from one egg of D. pini in nature is about 33. This rate of infestation should be maintained as closely as possible in the laboratory breeding of Trichogramma embryophagum.

*A female was observed in 1958 that has deposited over 340 eggs.

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THE SEASONAL CHARACTER OF HATCHING AND THE EMBRYONIC DIAPAUSE IN AĒDES CASPIUS DORSALIS MG. (DIPTERA, CULICIDAE)

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Mosquitoes of the genus Aēdes are very agressive bloodsucking insects and transmit a number of diseases. A.caspius dorsalis Mg is widely distributed within the Holarctic region. Information on its biology is sparse and is of a fragmentary nature. Very little study has been given to the biology of the egg stage, and without a knowledge of this we cannot gain a proper understanding of the seasonal nature of the hatching of the larvae of A. caspius dorsalis. The present paper is an attempt to fill this gap. The work was carried out in the neighborhood of Ivanovo.

As early as 1941 it was noticed that from egg batches of A. caspius dorsalis, laid in July, most of the larvae emerged shortly after being flooded. From eggs laid in September larvae could not be obtained after flooding, although larvae hatched out from these eggs in spring. This phenomenon naturally led to the belief that there was an arrest of development in the eggs of the autumn batches of A. caspius dorsalis [Khelevin, 1946b]. Hence from 1942 onwards, over a period of several years, we made a survey of the percentage hatch of larvae in relation to the time of egg laying. The results of our 1942 observations are collected in Table 1.

In June, July and early August we obtained 22 egg batches with a total number of 3428 eggs. From the eggs of this group 77.1% of the larvae emerged in the first summer-autumn season, and of these, 65.2% hatched out in the first ten days after submersion.

Yet 22.9% of the summer group did not hatch before December 1942. From the remaining eggs larvae continued to hatch out in winter 1942/1943 and spring 1943 in the laboratory. During the winter and spring period (before May 1, 1943) another 11.3% of the larvae emerged.

Thus there was a very pronounced irregularity in the emergence of A. caspius dorsalis. Some of the eggs had a long summer diapause, the origin of which can be explained, as in the case of other species of Aedes, by the adaptation to propagation in temporary waters. The percentage hatch of A. caspius dorsalis larvae from summer eggs did not show any constancy; on the contrary, it varied considerably in different years. For instance, in 1942 it was 77.1%, while in 1949 it was 92.8%.

In the second half of August 1942 the percentage of larvae hatching from eggs was very much less and in different batches varied from 0 to 66%, the average being 13.1%. This included 10 egg batches with a total of 1644 eggs. Hatching of larvae from the September egg batches in the laboratory did not take place until the first half of December. In September we obtained 11 egg batches with a total number of 1716 eggs. When these eggs were submerged in water no hatch of larvae was obtained, even when the eggs were kept permanently under water, which was repeatedly changed, at the end of the period of embryonic development, i.e., during September, October and November. Experiments involving the periodical removal of the eggs from water for 3-4 days followed by further submersion gave similar results.

In September and early October the temperature in the laboratory stayed in the range 15-21°C. The first hatch took place on Dec. 7, when two of the September egg batches produced 4 larvae (at 12°). Later, larvae

TABLE 1

Seasonal Nature of Hatching of Larvae of Aëdes caspius dorsalis

No. of group	Period of egg laying in 1942	Number of egg batches	Number of egg laid	Average percentage hatch from eggs before Dec. 7, 1942
1	From 5 VI to 9 VIII	22	3428	77.1
2	From 16 VIII to 28 VIII	10	1644	13.1
3	From 4 IX to 19 IX	11	1716	0

continued to emerge from these and other batches throughout the winter, although the temperature did not rise above 13°. An exception was the period from Jan. 1-Feb. 21, when the temperature in the laboratory fell to 4-8°C – below the lower threshold for emergence [Khelevin, 1944, 1946b]. Hence we must conclude that the delay in the hatching of larvae from the September egg batches of A. capius dorsalis can be explained only by the ability of this species to enter an embryonic diapause. In any case, this phenomenon cannot fit the conception of cold torpor. In the case of torpor the probability of larvae hatching from the eggs in September-October would have been higher, since the temperature in the laboratory was higher. It might be admitted that a certain reduction of temperature in autumn simply retarded the development of the larvae in the eggs. However, by opening up September eggs 10-13 days after laying we showed that the larvae in them were fully formed, although they were not capable of immediate hatching. Prolonged drying of the eggs during this period had no lethal effect on them either.

Even if we leave aside for the moment the question of the nature of the delay, we can conclude from the observations that the percentage hatch of larvae from A. caspius dorsalis eggs falls with the approach of autumn and is equal to zero in the September batches. Similar observations conducted in the following years confirmed this conclusion.

It was found, however, that the percentage hatch of larvae from eggs of the summer batches might reach 100, while a cessation of development of all the A. caspius dorsalis eggs was found in certain years in batches laid late in August and in other years – in those laid early in September (1947, 1949).

Observations conducted in field conditions also confirmed that in August there was a cessation of development of the eggs of A. caspius dorsalis. It was found that A. caspius dorsalis larvae of the later instars occurred in the waters up to the last days of October. First instar larvae during this period could be found only exceptionally, and yet in autumn the larval biotopes of this species are often filled with water, and on the soil underneath the eggs of Aëdes can be found. For instance, on Oct. 24, 1949, during a mild spell, we made a thorough search with a hoop-net in a water near Sokovskii Bridge, a typical larval biotope of A. caspius dorsalis. From the whole water we caught only 6 first-instar larvae and 1 fourth-instar larva (the first-instar larvae had already acquired dark pigmentation). On Nov. 4, 1949, during a mild spell, when the ice cover had partially thawed and was broken in places, 7 first-instar larvae were caught in this place after a long search. In spring 1950 in the same water more than a hundred larvae were caught with one sweep of the net. Thus, the delay in the hatching of larvae from the eggs was obvious even from field observations. At the same time it should be noted that in periods of mild weather the emergence of a few larvae from the eggs is possible. These results agree fully with observations made in the laboratory. However, field observations alone do not enable us to solve the question of whether there is an autumnal embryonic diapause or a state of cold torpor in A. caspius dorsalis. The following experiment goes some way toward answering this question. In autumn, pieces of turf were taken from a larval biotope situated in a marshy flood-plain with a large catchment area. The middle portion of the marshy region was flooded several times during the season, and larvae hatched out in the water. The turf was taken from areas bordering the water and also from flooded areas. The turf collected in October was brought into the laboratory and flooded with water. Either no hatch of larvae took place, or a few larvae hatched. In winter the turf was again flooded with water. A mass emergence of the larvae was observed. These experiments were conducted in 1946, 1948 and 1949, and with the same results. Table 2 shows the hatch of larvae from A. caspius dorsalis eggs in pieces of turf brought into the laboratory on Oct. 18, 1949.

TABLE 2

Autumn Cessation of Hatching of Aëdes caspius dorsalis Larvae from Eggs Laid in Natural Conditions

No. of sod	Size of sod (in cm)	Date of first flood-ding (1949)	Number of larvae hatching	Date of second flooding (1950)	Number of larvae hatching	Notes
1	25× 25	20 X	0	1 II	140	Turf taken from area bordering water
2	25 × 25	20 X	4	1 II	121	Turf taken from water under ice fringe
3	25× 25	20 X	2	1 II	289	Turf taken from area bordering water
4	25 × 25	20 X	0	1 II	69	Turf taken from water under ice fringe

Table 2 shows that practically no larvae hatched in October; from the same eggs in February, however, there was an abundant hatch of larvae. The mean temperature in the laboratory on Oct. 20 and 21, 1949 was even a little higher than on Feb. 1 and 2, 1950 (17.5°C on Oct. 20 and 21, 1949, 16.8°C on Feb. 1 and 2, 1950). Hence, the delay in the hatching of the larvae cannot be attributed to cold torpor, and the obtained results give us grounds for believing that during the evolution of A. caspius dorsalis an autumnal embryonic diapause has been developed.

It should be noted that for the experiments which demonstrate the existence of an autumnal embryonic diapause in A. caspius dorsalis, the turf must be taken from larval biotopes draining a large area, so that the area is flooded at least 2-3 times during the season and larvae hatch out in the water. If the turf is taken from larval biotopes which give only a spring brood of mosquitoes, and there is no second hatch from them, or the hatch owing to the small extent of the flooding is of a partial nature, then we might arrive at quite the reverse conclusion. This is due to the fact that the first broad of mosquitoes lay eggs which are incapable of falling diapause.

In order to discover the nature of the delay in the hatching of larvae from the eggs the following experiment was carried out in 1942: mosquito egg batches Nos. 33 and 34 (laid Sept. 4-5) were installed on Sept. 16 in a thermostat at temperature 23°C. Keeping the eggs at this temperature for 8 days did not result in the emergence of the larvae, though in the summer months there was a very high rate of emergence at 23°C.

Unfortunately this experiment, demonstrating the existence of an embryonic diapause in A. caspius dorsalis, was not on a large enouth scale and did not settle the question of whether hatching could take place from eggs of autumn batches at relatively high (summer temperatures).

Hence in 1949 we decided to repeat this experiment on a larger scale and to follow it to its conclusion. For this purpose 10 A. caspius dorsalis egg batches laid in September were separated into two groups. One portion of each egg batch was kept in the laboratory, and the other (equal) portion was installed in a thermostat at 25 or 30°C. The results of experiments on the hatching of larvae from eggs of September batches in thermostat conditions are given in Table 3, and the results of the control are in Table 4.

The eggs batches used in the experiment were obtained in the laboratory in the period between Sept. 5 and 16, 1949. They were kept on moist filter paper in small glass dishes in the laboratory for at least 11 and not more than 29 days, i.e., they were exposed to the action of low temperatures, at which in previous experiments the eggs had developed the property of delayed hatching. The egg batches were then installed in a thermostat at temperature 25 or 30°C and 96 hours later were flooded with water. In designing these experiments we took into account the results which we had obtained with summer egg batches in the previous year [Khelevin, 1946b]. In particular, we had noted that the development of larvae inside the egg could take place in damp surroundings as well as under water. The shortest time from egg laying to hatching was 5-6 days (at temperature 23.5°C). The water in the vessels containing the egg batches was changed periodically (once a week). Change of water, as we found earlier, had a very stimulating effect on the hatching of larvae from the eggs [Khelevin, 1946b]. In carrying out the experiment we introduced a modification for four egg batches out of the ten, i.e., the egg

TABLE 3

Hatching of Aëdes caspius dorsalis Larvae from September Egg Batches in Thermostat Conditions.

No. of egg batch	No. of eggs used in expt.	Date when laid	Date when submerged	Date of installation in thermostat laid	Hatch of larvae							
					before Oct. 1	ten-day periods in October			November	December-February	total	% hatch
						I	II	III				
At temperature 35°												
103	48	8/IX	27/IX	23/IX	0	2	2	0	32	1	37	77.1
110	56	9/IX	27/IX	23/IX	0	0	8	2	26	8	44	78.6
113	87	9/IX	27/IX	23/IX	1	0	0	8	40	2	51	58.6
116	114	10/IX	27/IX	23/IX	0	2	0	1	49	31	83	72.8
124	65	12/IX	27/IX	23/IX	1	0	3	1	48	0	53	81.5
Total	370	—	—	—	2	4	13	12	195	42	268	72.4
At temperature 30°												
91	117	5/IX	27/IX	23/IX	0	0	19	1	40	31	91	77.8
109	74	9/IX	19/IX	8/ X	0	1	0	0	0	54	55	74.3
125	61	12/IX	19/IX	8/ X	0	0	0	2	30	10	42	68.9
143	108	15/IX	19/IX	8/ X	0	0	0	38	37	1	76	70.4
146	89	16/IX	27/IX	8/ X	0	0	2	1	46	3	52	58.4
Total	449	—	—	—	0	1	21	42	153	99	316	70.4
Altogether	819	—	—	—	2	5	34	54	348	141	584	71.3

batches obtained in laboratory conditions were kept in the laboratory on wet filter paper for 4 to 11 days, and then were flooded with water, still in the laboratory, and kept there for 11-19 days. After this the egg batches were transferred (Oct. 8) to a thermostat at temperature 30°C.

TABLE 4

Hatching of Aëdes caspius dorsalis from September Egg Batches in Laboratory Conditions

No. of egg batch	No. of eggs used in expt.	Date when laid	Date when submerged	Hatch of larvae						
				before Oct. 1	October	November	December-February	following months	total	% hatch
91	117	5/IX	27/IX	0	0	1	68	25	94	80.3
103	49	8/IX	27/IX	2	0	0	16	19	37	75.5
109	73	9/IX	19/IX	0	0	0	45	14	59	80.8
110	57	9/IX	27/IX	0	0	0	40	1	41	71.9
113	88	9/IX	27/IX	0	0	0	66	2	68	77.3
116	114	10/IX	27/IX	0	0	2	84	9	95	83.3
124	64	12/IX	27/IX	0	0	0	44	0	44	68.7
125	61	12/IX	19/IX	0	0	0	26	24	50	81.9
143	108	15/IX	19/IX	0	0	1	73	8	82	75.9
146	90	16/IX	27/IX	0	0	0	59	3	62	68.9
Altogether	821	—	—	2	0	4	521	105	632	76.9

It was very characteristic that there was no immediate hatch of larvae from the eggs when they were flooded in the laboratory. Even after installing the egg batches in the thermostats, either no larvae at all hatched out in the first few days, or isolated larvae emerged from some of the egg batches. Only 2 larvae hatched out of 819 eggs before Oct. 1, 1949, 5 larvae in the first ten days of October, and a total of 93 larvae in the whole of October, i.e., 11.3%; in November the bulk of the larvae emerged—348 larvae (42.5%), in December—125 larvae (15.3%), in January—14 larvae, and in February—only 2. There was no further hatch of larvae (before November 1950). When the eggs were examined in November 1950 it was found that all the eggs left were misshapen. By opening up the eggs we confirmed that the larvae in the eggs had perished and by that time were decomposing.

The percentage hatch of larvae from eggs kept in the thermostat at 25°C amounted to 72.4%, while in the thermostat at 30°C it was 70.4%, the average being 71.3%.

A notable feature is the high percentage mortality of the eggs. This easily be explained on the grounds that the conditions under which development at this stage took place did not meet the requirements of the organism.

An analysis of the figures given in Table 3 shows that the autumn egg batches of A. caspius dorsalis show a delay in the hatching of the larvae, and this delay cannot be terminated straight away by the action of high (summer) temperatures i.e., A. caspius dorsalis has an autumnal embryonic diapause. Termination of the state of diapause is possible however, at relatively high temperatures.

We note that a few larvae (egg batches Nos. 113, 124, 109) hatched out from the eggs immediately after the flooded egg batch was installed in the thermostat or after flooding in the thermostat. This is reminiscent of the phenomenon of cold torpor and gives us grounds for asserting that the physiological processes producing the cessation of development are not uniform throughout the eggs of one batch.

An analysis of Table 4 also shows that the eggs of September batches are in a state of diapause. If we compare the hatch in October with the hatch in January, it is perfectly obvious that in October, at a mean monthly temperature of 16.3°C, there was no hatch of larvae from the eggs, although the temperature in the laboratory rose to 20°C; yet in January, when the temperature in the laboratory varied from 9.1 to 19.0°C, the mean monthly temperature being 14.1°C, a fairly considerable hatch of larvae took place. Opening of eggs in the first ten days of October showed, just as in the previous cases, that the larvae in them were fully formed. In the laboratory one larva in the control group (in batch No. 143) emerged during the first ten days of November. A few larvae from different egg batches continued to hatch out during December. In January the rate of hatching suddenly increased and reached its maximum in February. March and April were characterized by a gradual falling-off in the rate of hatching. In the months following April only solitary larvae were observed to hatch out.

TABLE 5

Duration of Embryonic Diapause in Aëdes caspius dorsalis in Conditions Approximating Natural

No. of subgroup	No. of eggs used in expt.	Date of return to lab. and flooding	Larvae hatching after flooding									
			during 1st ten days		during 2nd ten days		during 3rd ten days		subsequently		total	
			No.	%	No.	%	No.	%	No.	%	No.	%
1	463	3/XII	13	2.8	11	2.4	27	5.8	344	74.3	395	85.3
2	387	3/ I	25	6.5	47	12.1	106	27.4	123	31.8	301	77.8
3	443	3/ II	272	61.4	57	12.9	24	5.4	16	3.6	369	83.3
4	469	3/ III	381	81.2	7	1.5	0	0	4	0.9	392	83.6
5	442	3/ IV	360	81.4	5	1.1	0	0	0	0	365	82.6

A comparison of Tables 3 and 4 shows that in thermostat conditions (temperature 25-30°C) the rate of hatching reaches a maximum in November, while in laboratory conditions the maximum is in February. A few larvae in the thermostat emerged very much earlier.

From these experiments we can conclude that a relatively high (summer) temperature shortens the period of diapause in autumn eggs of A. caspius dorsalis, but also slightly increases the percentage mortalicy of the eggs.

Our analysis of the experiments showing the effect of high and moderate (laboratory) temperatures on the course of the embryonic diapause in A. caspius dorsalis gives no answer to two questions: 1)How soon do the eggs come out of diapause in natural conditions? 2) Do low temperatures shorten or extend the period of diapause?

We attempted to solve these questions in two sets of experiments. The first set was designed to establish the duration of the embryonic diapause of A. caspius dorsalis in conditions as close as possible to natural. For this purpose 30 egg batches of A. caspius dorsalis were divided into 2 equal groups (each egg batch was halved). One group was kept on moist filter paper in dishes in the laboratory and served as a control; the other group was also kept on moist filter paper in similar dishes but was placed outside (on the ground) close to the building, under an awning. The development of the eggs used in the experiment was again stopped in laboratory conditions. Check dissections and flooding of the eggs showed that the larvae in them were fully formed, but no hatch took place (apart from isolated larvae).

Oct. 3, 1947, half of each egg batch was brought out into the open and placed in the described conditions. The portions of the egg batches brought outside were further divided into 5 approximately equal subgroups. One of the subgroups was brought into the laboratory and flooded with water after one month Nov. 3), another subgroup—after 2 months, the third—after 3, the fourth—after 4, and the fifth subgroup was brought into the laboratory and flooded with water in spring(May 3, 1948), i.e., after 5 months. Further observations on the hatching of larvae from eggs subjected to cold continued until Nov. 18, 1948. Observations on the control group were also terminated at the same time.

From an analysis of Table 5 it can easily be observed that the longer the eggs of A. caspius dorsalis spend in conditions approximating natural, the more concerted is the emergence of larvae from the eggs. The group of egg batches brought into the laboratory on Dec. 3, 1948, and flooded with water did not give such a concerted hatch of larvae. The hatching of the larvae extended over a period of several months, the bulk of the larvae hatching in January-February, 1948. The hatch of larvae from the eggs in this subgroup was very similar in character to the hatch from the control batches (Table 6). We do note, however, a certain increase in the rate of hatching in the subgroup kept in conditions approximating natural, i.e., subjected to cold. In this subgroup the greatest hatch of larvae took place in January, as compared with February in the control. The length of the period of hatching clearly shows that by December the main mass of A. caspius dorsalis eggs in natural conditions have still not

TABLE 6

Hatching of Aëdes caspius dorsalis Larvae from September Batches in Laboratory Conditions

No. of subgroup	No. of eggs used in expt.	Hatch of larvae										
		before Oct. 1	October	November	December	January	February	March	April	succeeding months	total	% hatch
1	464	0	0	1	21	144	167	19	7	2	361	77.8
2	387	0	0	1	21	78	167	13	6	1	287	74.2
3	444	1	0	1	24	82	159	51	2	6	326	73.4
4	466	1	0	0	39	97	163	39	6	13	358	76.8
5	442	2	0	0	7	93	226	17	5	3	353	79.9
Total	2203	4	0	3	112	494	882	139	26	25	1687	76.6

Egg batches brought into the laboratory and flooded with water on Jan. 3 gave a more concerted hatch of larvae. The bulk of the larvae hatched in the course of four ten-day periods. Yet solitary larvae continued to emerge right until July. One egg batch showed an unusually long delay in the hatching of the majority of the larvae (No. 228); in this batch 81% of the total numbe of larvae which emerged did not hatch out until May.

If we compare the rate of hatching in the second subgroups of the experiment and control, we can clearly conclude that cold has a stimulating effect on the hatching of larvae from the eggs. Low temperatures shorten the period spent by the egg in a state of diapause. Of the eggs which were kept in the open, i.e., subjected to cold, and flooded on Jan. 3, 1948, 59.1% of the larvae (of the total number of larvae which hatched during the period of the experiment) hatched out in the course of 30 days, while in the control only 27.1% of the larvae emerged during January.

The hatching of larvae from eggs in subgroups brought into the laboratory on Feb. 3, 1948, March 3, 1948 and Apr. 3, 1948 took place within still shorter periods. In the February subgroup the bulk of the larvae hatched during the first 20 days, though a few larvae hatched out in the following months.

In the subgroup brought into the laboratory and flooded with water on Apr. 3, the hatch of larvae from the eggs was concerted: 98.7% of the larvae hatched in a ten-day period, and the remaining 1.3% hatched in the following ten-day period. It should be noted, however, that even in egg batches in which the hatch of larvae was completed, it was irregular during the ten-day period.

From a comparison of Tables 5 and 6 we can also conclude that A. caspius dorsalis eggs can come out of diapause both in laboratory conditions at positive temperatures, as well as in natural conditions at negative and near-negative temperatures. However, the average percentage hatch from eggs which wintered in conditions close to natural was somewhat higher than the average percentage hatch from the group of eggs kept in laboratory conditions (82.6 and 76.6%). A repetition of the observations in other years gave similar results.

If, however, we compare the percentage hatch from each egg batch separately, the percentage hatch in individual batches of the laboratory group was equal to, or even higher than, the percentage hatch from groups which wintered in natural conditions. This is due to the fact that the causes of mortality of the eggs were different in the winter period. For instance, egg batches in the laboratory were frequently attacked by mold. In these batches the percentage hatch was a little and sometimes even considerably lower than the average. Keeping the eggs in the open on moist filter paper in dishes also had a number of drawbacks: at temperatures below zero the excess water in the dish froze, the glass developed a crack, and during a mild period the filter paper would act adversely by drying up the eggs. Elements of chance in dividing the egg batches into groups might also have been operative.

TABLE 7

Duration of Embryonic Diapause in Aëdes caspius dorsalis

No. of group	Period of egg laying	Treatment of eggs in year of laying	Number of eggs used in experiment	Number of larvae hatching before 18/XI/1948	Number of eggs left on 18/XI/1948	Treatment from 18/XI/1948 to 12/IV/1949	Date of hatch	Number of larvae hatched
1	Sept., 1947	Chilled	2204	1822	223	Chilled in natural conditions		0
2	Sept., 1947	Not chilled	2203	1687	239	Chilled in natural conditions	18/IV/1949	6

The retention of viability of the eggs obviously depends mainly on how far the abiotic external factors, i.e., temperature and moisture, in the winter period correspond to the requirements of the organism at its particular stage of development.

It should be pointed out, however, that the causes of mortality of the eggs were not the subject of our investigations, and this question will require additional study.

By comparing the data given in Tables 4 and 6 with the temperature conditions in the laboratory* we found under what temperature conditions embryonic diapause developed in the autumn eggs of A. caspius dorsalis. The diapause in the eggs of A. caspius dorsalis in autumn 1949 developed in eggs of different batches in a relatively narrow range of average temperatures: from 15.6 to 18.3°C. The average temperatures in the laboratory in September 1947 varied from 15.9 to 18.2°C for the different egg batches. The maximum temperatures in 1947 reached 19-23°C, while the minimum temperatures varied between 13.3 and 16°C. Thus, we can consider it proved at that even at a relatively high average temperature (17.4-18.3°C) an embryonic diapause can develop in A.caspius dorsalis eggs. It is obvious, however, that the above-mentioned high average temperatures are not perfectly suitable for the development of embryonic diapause, since shortly after their submersion a few larvae emerged from the eggs of certain batches (egg batches Nos. 224, 226 and 230, 1947 and egg batch No. 103, 1949). It should be noted that the water temperature at the hours of hatching was never less than 18.2-18.3°C. A similar effect took place in 1950. In other years, at lower temperatures, no hatch of larvae from the September batches took place.

An analysis of Tables 5 and 6 shows that not all the A.caspius dorsalis eggs, whether kept in laboratory conditions or overwintering (entirely or partially) in surroundings close to natural, gave a hatch of larvae.

Observations on the experiments summarized in Tables 5 and 6 continued up to Nov. 18, 1948. The bulk of the larvae hatched out during winter even in laboratory conditions. A few larvae, however, hatched before July 1948 (inclusive); after this hatching of larvae ceased. During 3 months (May, June, July) 25 larvae hatched in the laboratory group, and of these, 13 larvae out of egg batch No. 275 (an exceptional case) emerged in May, 1948. Hence only 12 larvae out of all the other egg batches hatched out during this time.

From the number of eggs which overwintered for different periods in conditions very close to natural, only 8 larvae hatched out in the May-June period, and of these, 5 emerged from the first subgroup, which was exposed to cold in natural conditions for only one month; 3 larvae emerged from the second subgroup. In the second subgroup the larvae were born in May. In the third, fourth and fifth subgroups, which were kept in natural conditions for 3-5 months, the hatch of larvae finished before May, although the fifth subgroup was brought into the laboratory and flooded on April 3.

From the set of experiments just examined we can also conclude that the embryonic diapause in A. caspius dorsalis, in laboratory and natural conditions, terminates much earlier than the spring thaw. During winter, though at different times, most of the eggs come out of diapause and hatch in laboratory conditions, while in natural surroundings and after termination of diapause they are in a state of torpor. It can be stated that the main mass of eggs come out of diapause during January-February in laboratory conditions (Table 6) and by February in natural conditions (Table 5, second and third groups). The majority of eggs brought into the laboratory from outside in February slowly come out of their torpor and give a hatch of larvae. It is obvious that the longer the eggs of A. caspius dorsalis are kept in conditions approximating very closely, natural, the more concerted is the hatch of larvae. Hence the probability of eggs being found in a state of diapause in natural conditions in spring, after the filling of the future larval biotopes, is very slight.

On Nov. 18, 1948, our observations on the hatching of larvae in the two groups were stopped; some of the eggs had perished (were misshapen), and others were lost when the water was changed. On Nov. 18, 1948 in a group of eggs which had formerly been exposed to cold in natural surroundings we found 223 eggs, which to outward appearance were perfectly viable. In the laboratory group we found 239 eggs which still retained their shape. On this day, taking advantage of a mild spell, we took all the remaining eggs outside and installed them on damp filter paper in the above-mentioned dishes under the awning. On May 12, 1949 both groups of eggs were returned to the laboratory and flooded with water. From the eggs which had been kept all the time in the laboratory during the first year, 6 larvae emerged on May 18, 1949 (5 larvae in egg batch No. 232 and 1 larva in egg batch No. 242). In the group of eggs which had been exposed to cold in the year of laying, no hatch of larvae took place.

*In our investigation of the temperature conditions in the laboratory we measured the air and water temperature 3 times a day (at 8 a.m., 1 p.m. and 7 p.m.) over a period of several years.

TABLE 8

Stimulating Action of Negative Temperatures on Hatching of Aëdes caspius dorsalis Larvae from Eggs in a State of Diapause

Number of eggs used in expt.	Hatch of larvae						
	October	November	December	January	Succeeding months	Total	% hatch
321	24	7	17	81	103	232	72.2

It should be pointed out that most of the A. caspius dorsalis eggs taken on Nov. 18, 1948 retained shape up to April 12, 1949. In September 1949, however, it was found that the bulk of the eggs in both groups were mis-shapen. By opening the eggs left we found that the larvae in them had perished and were decomposing. Further observation on this experiment was not worthwhile.

The results of this experiment are given in Table 7.

This experiment first of all answers the question of the duration of diapause in A. caspius dorsalis in conditions differing from the normal for the particular stage of development. The embryonic diapause in A. caspius dorsalis in laboratory conditions may last for more than a year. The autumn eggs of this species of mosquito require low temperatures for thir development, which is accompanied by the gradual removal of diapause. This is clearly shown not only by the experiment given in Table 7 but also by the results given in Tables 5 and 6.

If the temperature conditions do not favor the course of the embryonic diapause in A. caspius dorsalis, the development leading to its termination may be delayed for a long period—up to 15 months. Some of the eggs in a state of diapause can retain their viability for 15 months and after a period of chilling in natural conditions are able to give a hatch of perfectly viable larvae.

When the diapausing eggs have been exposed to cold in natural conditions for 1-5 months, there is not such a long delay in the hatching of larvae from the eggs. If the period of development in low temperature conditions is not long enough (1-2 months) the hatching of some of the larvae is held up until July. Another exposure to cold in natural conditions does not produce a hatch of new batches of larvae; in these conditions diapause may still be terminated, though with certain difficulties. Hence, the embryonic diapause of A. caspius dorsalis is a stage of development of the organism which normally requires low temperatures for its accomplishment (in our latitudes).

In summing up the results of our experiments into the effect of high and low temperature we get the impression of a contradiction in the demands made by A. caspius dorsalis during embryonic diapause on the conditions of its existence On the one hand we have concluded that a relatively high temperature shortens the

TABLE 9

Hatching of Aëdes caspius dorsalis Larvae from September 1948 Egg Batches in the Laboratory

Number of eggs used in expt.	Hatch of larvae						
	October	November	December	January	Succeeding months	Total	% hatch
322	0	0	12	53	153	218	67.7

period of diapause in autumn eggs of this species, and on the other hand we are stating that this stage of development requires a low temperature, which also shortens the period of diapause. This flexibility in adaptation to external conditions may find its explanation in the origin of the species. A. caspius dorsalis is a Holarctic form which obviously originated in the Palaearctic, but it still retains features peculiar to tropical species, which leads us to believe that the ancestors of this species were tropical forms of the genus Aëdes. Yet the new species bears "traces" of the old, and these "traces" enable the species to spread far south, as far as the Ethiopian region [Hopkins, 1936],* while the newly acquired qualities, such as the frost tolerance of the eggs (to −43 C, [Khelevin, 1944]) and the presence of an autumnal embryonic diapause, have enabled the species to dwell even within the Arctic circle (Tazovskaya Bay [Kiseleva, 1927]).

It should be pointed out that, in all the experiments we have described, the diapausing eggs of A. caspius dorsalis were subjected to prolonged action of high or low temperatures over periods measured in months. To fin find out the effect on the diapause of short-term action of low (negative) temperatures we took for experiment 5 egg batches of A. caspius dorsalis (Nos. 104, 105, 106, 107, 108) obtained in the laboratory in September 1948. These egg batches were exposed twice to the action of low temperatures Oct. 14 and 28, 1948). The duration of the chilling in each case was 12 hours. For obtaining the low temperatures we used a freezing mixture (crushed ice and salt). Each of the egg batches used in the experiment was divided into two equal parts: one of them was the control and was kept in the laboratory, the other portion of each egg batch was exposed to chilling. The temperature was lowered to 20°C. After chilling the egg batches they were flooded with water on the same day. The results of this experiment and the control experiment are brought together in Tables 8 and 9.

An analysis of these tables brings us to the conclusion that low (negative) temperatures stimulate the hatching of larvae from eggs in a state of diapause. In the chilled group we noted an unusually high percentage hatch in October. We should add to this that for the experiment we used eggs of the late September laying in which the diapause is usually very definite. In the control group, composed of portions of the same egg batches, there was no hatch of larvae either in October or in November 1948.

Thus, low temperatures not only promote a gradual termination of diapause during development in the winter period, as we saw from the previous set of experiments, but also have a stimulating effect on hatching. The latter refers to negative temperatures. It should not be forgotten here that the percentage of prematurely hatching larvae was very small; hence we conclude that short-term chilling cannot terminate diapause in the main mass of eggs of the late September layings. On the other hand, the experiment shows that in autumn, just as in summer, eggs of the same batch are in different states, and vary in their response to the same external factors.

We have already mentioned that, besides the autumnal embryonic diapause, which is an adaptation ensuring the survival of the species in the autumn-winter period unsuitable for its development, we also find a summer embryonic diapause in some eggs of A. caspius dorsalis.

The summer embryonic diapause, so characteristic of all Aëdes species, obviously arose in the process of evolution as a result of adaptation to propagation in temporary waters. It is manifested in A. caspius dorsalis in the irregularity of the hatch of larvae from eggs of the summer batches.

In different years 7.2 to 22.0% of the eggs of the summer batches do not give a hatch of larvae during the first summer-autumn season. Some of the larvae from these eggs do not hatch out till the winter or the following spring. Temperature conditions have a great bearing on the termination of the summer embryonic diapause in A. caspius dorsalis eggs.

Out of 268 eggs laid in summer 1947 and which did not give a hatch after repeated floodings during the warm season, only 19 larvae, i.e., 7.1% hatched out in the following winter and spring in the laboratory.

The results of experiments on summer egg batches of 1948 and 1949 showed that if A. caspius dorsalis eggs laid in summer and which have not hatched before winter are kept in conditions close to natural, they are capable of producing a considerable hatch—up to 48.6% (89 larvae hatched out of 183 eggs)—in the spring. Hence, A. caspius dorsalis eggs in a state of summer embryonic diapause differ from eggs in a state of autumnal diapause in their response to the same environmental conditions.

*We consider that A. caspius dorsalis Meigen and A. caspius caspius Pallas are geographical subspecies [Monchadskii, 1951].

SUMMARY

1. Two types of embryonic diapause, a summer and autumnal diapause, are observed in the mosquito Aëdes caspius dorsalis. The origin of the summer embryonic diapause is obviously associated with the adaptation of the organism to propagation in temporary waters. The autumnal diapause arose as an adaptation to severe winter conditions.

2. The hatching of A. caspius dorsalis has a distinct seasonal character. The seasonal character of the hatching is due in the first place to the presence of an autumnal embryonic diapause. Relatively high (summer) temperatures shorten the period of diapause in autumn eggs of A. caspius dorsalis. Negative temperatues, also promote the termination of diapause. The number of larvae hatching from diapausing eggs is directly related to the duration of exposure to cold. Under the action of low temperatures the main mass of eggs break their diapause during January and February. When they winter in conditions close to natural, all the viable eggs are reactivated.

3. In conditions uncongenial to the course of the embryonic diapause the development leading to its termination may be delayed for a considerable period of time. Some of the eggs in a state of diapause can retain their viability for 15 months and after a period of chilling in natural conditions give a hatch of perfectly viable larvae. Hatching of larvae from eggs which diapaused for 15 months is delayed almost to the third warm season.

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ON THE ECOLOGY AND SUMMER-AUTUMN PHENOLOGY OF THE COMMON MALARIAL MOSQUITO ANOPHELES MACULIPENNIS MG. VAR. SUBALPINUS H. L. IN THE SOUTHEAST COASTAL AREA OF AZERBAIDZHAN

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During an investigation into the species composition and distribution of bloodsucking mosquitoes of the subfamily Culicinae (Diptera, Culicidae) in the Lenkoran region of the southeast area of the Azerbaidzhan SSR in 1956 the author also made a study of the ecology and some aspects of the phenology of A. maculipennis, the main vector of malaria in the lowland region of the southeast coastal area of Azerbaidzhan.

The present paper represent an approach to some of the basic problems of the ecology and phenology of the imaginal phase of A. maculipennis; as regards the ecology of Anopheles larvae, this has been the subject of a thorough study by the staff of the Central Institute of Malaria, Medical Parasitology and Helminthology of the Ministry of Health USSR [Ivanova and Polovodova, 1942]; as regards the species composition of Anopheles and the varieties of A. maculipennis in the different landscape zones of the coastal area of Azerbaidzhan, these questions have been studied by several authors [Bogoyavlenskii, 1936; Ivanova and Polovodova, 1942; Zolotarev, 1945; Remennikova, 1953].

The researches of L. V. Ivanova and V. P. Polovodova [1942] and V. M Remennikova [1953] revealed that the distribution of the different varieties of A. maculipennis within the southeast area of Azerbaidzhan was related to the particular landscape zones. From a study of egg batches these authors found that A. mac. subalpinus H. L. predominates in the damp area of the lowland; in the northern part of the lowland A. mac. subalpinus H. L. gives way to A. mac. sachorovi Favre with approach to the dry steppes; in the hilly foothill zone A. mac. subalpinus H. L. is joined by A. mac. maculipennis Mg. In the mountain zone A. mac. typicus is the only form of this species.

As a fixed locality for observations in 1956 we chose a sample inhabited area on the territory of the Lenkoran district of Azerbaidzhan on the "Pravda" Collective Farm in Girdani, situated on the left bank of the R. Lenkoran-Chai at a distance of 8 km northwest of Lenkoran and at a height of 20 m above sea level. In the intervals between observations we made periodic trips through other settlements and districts. The area selected was typical of the lowland and was extremely rich in Anopheles-breeding waters. No measures at all against mosquitoes or their larvae have been taken here. Within the area of the investigations Anopheles maculipennis is distributed everywhere, being found in outhouses and in nature. Besides being found in outhouses, this species was also found in thickets of herbaceous vegetation in woods and was caught on a number of occasions in the forest zone at more than 700 m above sea level, in tree holes and abandoned wells. Despite repeated searches we never once managed to find this species in rodent burrows or in caves.

During our work we dealt with one form of A. maculipennis, namely its subspecies A. mac. subalpinus H. L.

1. Natural Conditions of Locality and Climate

The locality described is distinguished by a great diversity of geomorphological features, vegetation and climate. The Lenkoran district (Talysh) occupies the extreme southeast area of the Azerbaidzhan SSR.

As regards physical geography it is divisible into two areas: 1) the mountain area and 2) the lowland area, or coastal plain.

The mountain area consists of a high plateau where the mountains alternate with fairly broad river valleys. At different heights on the mountain ranges there are fairly deep hollows in which we usually find settlements.

The lowland area, or coastal plain, extends in a narrow strip at the foot of mountains along the shore of the Caspian Sea from south to north, reaching its greatest width in the north (25 km) and narrowing in the south (less than 7 km). Characteristic of the climate of this locality is the high annual precipitation, mild winter, moderately hot dry summer, and very wet autumn. The greatest precipitation is found in the autumn-winter period, when 50% of the annual precipitation occurs, and the least—from the second half of spring to the first half of August, the rainfall being so slight that this period can be called dry. As an illustration we give the mean data on the distribution of precipitation over the seasons, calculated from several years observations: spring 17.6%, summer 8.8%, autumn 52.7% and winter 20.9% of the annual precipitation.

In the southern part of the lowland, bordering the Caspian Sea (Astara) the annual precipitation is 1400-1700 mm, which is typical of damp subtropical regions.

In the northern part of the lowland the annual precipitation is very much less, while the mean annual temperature amplitude is higher. The mean annual temperature is 14° or more, and in places even fluctuates around 15°.

The mean monthly and annual air temperature from several years' records of the meteorological station of the Lenkoran Regional Experimental Station can be characterized by the following figures:

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual Temperature
3.1°	4.1°	7.0°	11.5°	17.6°	22.5°	25.7°	24.9°	20.8°	16.2°	10.3°	6.0°	14.1°

The mean temperature of the coldest month, January, is more than 0°, i.e., the winter is mild and warm. Toward the mountains the temperature falls in a regular manner (0.3° for 100 m rise). The hottest months are July and August when the mean temperature rises to 25° or more. With approach to the mountains the temperature falls in a regular manner (0.6° for 100 m rise), becoming 15° or less at heights about 2000 m above sea-level.

The length of the period of the year in which the air temperature ensures the completion of the cycle of sporogony is 5½ months on the lowland. In mountain regions the air temperature is lower, and the periods when malarial transmission is possible are shortened. Characteristic of the southern part of the lowland is the high humidity. In the low and middle forest zones the humidity varies between 70 and 100%, falling in the upper mountain zone to 50-70%. In the zone above 800-1000 m (north of the Kyz-Yurdu mountains) the humidity is much lower.

2. Types of Shelters

The Girdani-Chai stream flows through the center of the settlement and divides it into two parts. The settlement contains more than 200 homesteads, two thirds of which are located on the right bank of the stream. The houses here are scattered about. Most of the homesteads are unfenced. The buildings are mainly of baked brick and roofed with tiles; some of the houses and outhouses are of clay-and-framework construction, with reed-thatched roofs. This type of house construction is related to the climatic conditions of the locality, since buildings made of other materials could not withstand the abundant rainfall which occurs in the Lenkoran district. The principal Anopheles-breeding waters (rice fields, irrigation reservoirs etc.) lie on the left bank of the stream toward the southeast, at a distance of 150-200 m from the settlement. In choosing the site for our investigations we were guided by the rule that the larval centers should be close to the chosen sample daytime shelter, since it is well known that the closer these shelters are to the larval centers, the more they attract mosquitoes, other conditions being equal.

For carrying out our observations we selected a few sample buildings on the left bank between the stream and the rice fields. As such we took 3 sample daytime shelters: sample shelter No. 1—a cowshed with food,* sample shelter No. 2—a storehouse without food, sample shelter No. 3—a reed awning without food. Besides these, we chose one sample shelter under the verandah of a house.

Of these buildings the cowshed and storehouse can be classed as eustatic, and the reed awning and shelter under the house verandah as astatic.

Sample shelter No. 1—the cowshed with food—was a closed building surrounded on three sides by walls of unbaked brick, the fourth wall being that of the dwelling house. The thickness of the walls of the cowshed did not exceed 0.5 m. On the right side of the entrance there was a window. Opposite the entrance there was a small half-ruined opening, which promoted ventilation. The area of the cowshed was 5 × 3 m, and the height 1.9 m. The floor was of board, consisting of beams underpinned on the outside, with planks across them. On the roof of the shed there was a loft, open on three sides and roofed with a reed thatch; in this loft the inhabitants of the house spent the night. Thus, the cowshed was situated under the loft. Besides the cowshed we regularly inspected the thatch of the loft; mosquitoes were found here relatively rarely, apparently because of the strong draft.

The illumination of the building was uneven. The walls at the entrance were light, while the corners were darkened. In spring a calf was kept in the shed during the day and night, and the cow was brought in for the night. The cowshed was cleaned out daily; in summer, from July to Autumn, the cow and calf were kept outside at night near the house. During the summer period the inhabitants lived outside. Female mosquitoes which had fed on blood outdoors settled in all the buildings, mainly the nearest and most accessible, including the cowshed. Hence, in spring and autumn the mosquitoes attacked people and animals indoors, and in summer—outdoors. Hence the cowshed was more of a refuge than a feeding site. In spite of this, we classed sample shelter No. 1 (cowshed) as a eustatic shelter, although in its construction this shelter was to a certain extent astatic.

Sample shelter No. 2—storehouse without food—was a relatively closed building alongside the walls of the house. The entrance was from outside. There was a small window on the right side of the door. On the front wall near the door and on the right there was a small opening accessible to mosquitoes. The area of the room was 3.5 × 2.5 m, the height 1.8 m. The ceiling and walls were of plaited rush, the floor and walls were daubed with clay. The room was half-dark. The mosquitoes were found mainly on the ceiling and walls, in dark spots. For comparison we several times measured the temperature and relative humidity in all the corners of the ceiling and floor, and found there were no great variations in temperature or humidity. The sample shelter was very congenial in its microclimate and very suitable for catching mosquitoes.

Sample shelter No. 3 was a reed awning, of distinct astatic type, constructed on four beams of length 5 m; it was about 2.5 m high in the center, 1 m at the outer wall, with a reed thatch. The awning stood in the middle of the yard. The conditions in this shelter were similar to those of the open air, and there were large daily fluctuations of temperature and relative humidity.

Sample shelter No. 4—under the verandah of the dwelling, was a shelter of astatic type; over this shelter the inhabitants of the house spent the night during the summer. The shelter was open on three sides. The degree of air movement (draft) here depended on the direction of the wind. The shelter served as a refuge for mosquitoes and provided them with some protection against direct sunlight. In this shelter we found mosquitoes in darkened spots between the beams.

3. Description of Waters

The main waterway of the Lenkoran district is the R. Lenkoran-Chai. The length of the river is 81 km, drainage area 1080 m^2, the mean annual catchment being 215 million m^3, of which 25% falls in winter, 36% in spring, 7% in summer and 32% in autumn. Besides this, there are numerous smaller rivers, such as the Girdani-Chai, Boladi-Chai, Sudasharu-Chai, Soldat-Chai and others, which rise in the hills of the Talysh Ridge. In addition to the rivers there are numerous temporary waters, irrigation canals, reservoirs for rice irrigation—so called "istili," rice-field waters, springs etc. which serve as breeding places for Anopheles.

*Food = human or animal host.—Translator.

The periodic flooding of the largest rivers of the lowland prevents the development of rooted vegetation with the exception of a few small bank plants. The shallow rivers approach the Caspian with such a weakened current that they cannot cut through the coastal embankment and in their lower course form marshes which serve as breeding places for malarial mosquitoes. Of the above-mentioned types of waters the following are important as Anopheles-producers in Girdani: The R. Girdani-Chai, temporary reservoirs for rice-field flooding, the rice fields and the numerous temporary waters formed as a result of the abundant rainfall and the irrigation system.

The Girdani-Chai is a small river. The main breeding place of A. maculipennis is the flood-plain of the river. In spring and late autumn, floods caused by heavy downpours make it unsuitable for the breeding of mosquitoes. Toward the end of June and early July the river becomes shallow; the current speed falls, and along the banks there appear isolated stagnant flood-plain waters which are well heated and in which plants develop.

In these flood-plain waters we caught A. maculipennis larvae among the herbaceous vegetation, both in standing waters and in slow-flowing backwaters of the river.

"Istili" (reservoirs for rice-field irrigation). Of all the types of waters found in the lowland zone, the "istili" represent waters with exceptionally rich vegetation consisting of various physiognomic groups. The role of "istili" as breeding places of Anopheles is a very minor one and is limited to a short portion of the season. In early May the conditions in the "istili," in view of their size, are not congenial to Anopheles larvae (the mean temperature in them is much lower than the mean air temperature); it was not until the end of May that we found instar I-II Anopheles larvae in them. By the end of June the "istili" are usually completely overgrown with reeds, and in August, when the flooding of the rice fields stops, they dry up. Summer-brood larvae of A. maculipennis develop in the "istili".

"Bidzhari" (rice-field waters). In May the rice fields are not in use. Usually the seedlings are grown in special nurseries early in spring before being transplanted into the field. Near the nurseries there form numerous shallow waters, ditches and hollows filled with water, and these give broods of Anopheles in late May and June.

The rice fields are supplied with water from the "istili" and are periodically filled, but they never dry up completely; the greatest depth of water in them does not exceed 30-40 cm, and 50 cm in summer. The height of the newly planted rice is 10-20 cm, and by the middle of the growing period its height is 80-90 cm. In midsummer the main mass of Anopheles in the shelters was provided by the rice fields. From mid-August the rice harvest begins. After the harvest the ditches in the rice fields are sometimes filled again with rain water (September-October), and in the autumn period these ditches may be partially responsible for the slight increase in the numbers of mosquitoes in the shelters.

Thus, in the spring period the majority of the mosquitoes in the shelters came from the small, well-heated waters formed due to the abundant rainfall and the presence of an irrigation system; in the summer period they came from the rice fields, and partially from the "istili" and R. Girdani-Chai, and in autumn—from the Girdani-Chai and partially from the rain-filled rice fields after the rice harvest. Thus, the center of larval abundance during the season shifts from one type of biotope to another.

4. Seasonal Variation of Numbers

The collections of mosquitoes in the daytime shelters and the deduced mean size of catch (the data on the numbers of mosquitoes in different types of shelters are given in Table 1) gave an indication of the seasonal variation in numbers of the mosquito population.

The curve showing the seasonal variation in numbers in all the sample shelters remained at a high level, which can be attributed to the large area and high productivity of the waters in the "Pravda" Collective Farm.

An analysis of the curves shows that in all three sample shelters we find a one-peak curve, since in connection with the rice planting there are created here large areas of water with optimal temperature and other conditions for the development of larvae in the hottest part of summer, when the broods develop in the shortest time.

TABLE 1

Numbers of Anopheles maculipennis Mg. per Single Catch in Sample Shelters of Different Types in the "Pravda" Collective Farm

No. of sample shelter	Type of shelter	Total number of mosquitoes caught	Number of catches	Mean number per catch
1	Cowshed	8746	33	265.03
2	Storehouse	11,552	33	350.06
3	Awning	7868	33	238.4
4	Under verandah of dwelling	898	9	99.8
5	Latrine	493	9	54.8

As we see from the curves of the seasonal variation of numbers (Fig. 1), the lowest numbers of A. maculipennis occur in May in all the sample shelters. In the 6th five-day period of May, 18 mosquitoes were caught in sample shelter No. 1 (cowshed) and 5 in sample No. 2 (storehouse); mosquitoes were absent altogether from sample shelter No. 3—the awning. With the beginning of rice cultivation there is formed a large number of waters with optimal temperature conditions for the development of the larvae. These conditions bring about an increase in the numbers of the summer populations of mosquitoes in all the sample shelters.

From the 2nd half of June the numbers of mosquitoes rapidly increase and by the end of June - early August reach a peak in the sample shelters; the curve of seasonal variation of the numbers of mosquitoes reaches a peak in sample shelters No. 1 and No. 2 in the 2nd five-day period of August, and in sample shelter No. 3—in the 1st five-day period of August. From the second five-day period of August the curve falls steeply. Several factors contribute to the fall in the numbers of mosquitoes in mid-August. This drop in numbers is due, first, to the reduction in the area of water resulting from the drying-up of the rice fields before harvesting; secondly, to the slowing down of ovarian activity in a small proportion of females (there is a gradual increase in the numbers of diapausing females and a fall in the number of gonadally active, egg-laying females); thirdly, to the climatic factors becoming uncongenial for the mosquitoes. In September there was occasionally observed a new small rise in numbers. The September rise, as we indicated above, follows according to the time of the summer restoration (in August) of the Anopheles-breeding bank zone of the R. Girdani-Chai and the partial filling of the rice fields with rain water after the rice harvest.

As we see from Table 1, the mosquitoes were most dense in sample shelter No. 2 (storehouse)—the average number of mosquitoes in the storehouse per catch during the season was 350.06. Second,as regards density of mosquitoes,came sample shelter No. 1 (cowshed); here we should point out that in the cowshed with food there were less mosquitoes than in the storehouse without food. This can be attributed to the following factors: first, the cowshed is not so much a feeding site as a refuge, since in summer, from late June - early July, the cow and calf were kept outdoors near the house; females which had fed on blood outside entered the cowshed and some settled there, remaining till the end of the gonotrophic cycle; secondly, the climatic conditions were adverse.

At the time of the increase in the numbers of the mosquito population during the growth of the rice, the temperature in the cowshed was higher and the relative humidity lower than in the storehouse and, besides this, there was a slight draft in the cowshed. The situation was quite different in the reed awning. Here the greatest numbers of mosquitoes were restricted to a short portion of the season determined by climatic factors. In the spring period, owing to the cooling at night, there were no mosquitoes at all under the awning. In late May-early June the mosquitoes began to appear, and in August their numbers attained a maximum: during the day, when the temperature was high we still found large numbers of mosquitoes under the awning in the 1st five-day period in August we caught 1268 mosquitoes; the maximal daily temperature under the awning at 1 p.m. was 29.9° and the relative humidity 64%). These facts can be explained in the following way: sample shelter No. 3 (reed awning) was situated nearer the rice fields than the other sample shelters, and as a result a considerable number of mosquitoes were found under the awning. Climatic factors at the time of entrance of the mosquitoes

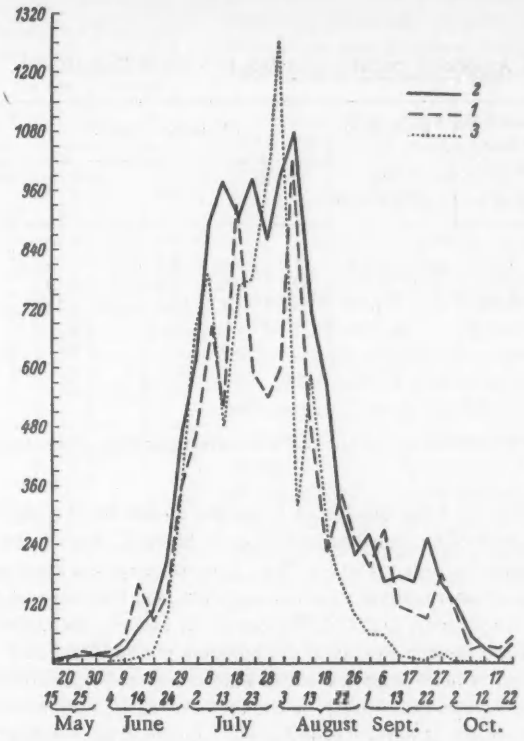

Fig. 1. Seasonal variation in numbers of adult Anopheles maculipennis subalpinus H. L. in shelters of different type in the rice zone in the "Pravda" Collective Farm (1956). 1) Cowshed with food; 2) storehouse without food; 3) awning without food.

were favorable. During the day, with the onset of heat, the mosquitoes had to remain there until evening, and with the onset of the evening cold they migrated into a more congenial shelter, where they remained until the end of the gonotrophic cycle.

In view of these circumstances the reed awning can be classed as a one-day shelter of astatic type.

It should be noted that for the lowland zone of southeast Azerbaidzhan a two-peak curve of seasonal variation in numbers of A. maculipennis is typical, but owing to the optimal temperatures and the existence of large breeding areas the curve of the numbers here (in the rice zone) maintains a one-peak character with a maximum in July-August.

5. Biological Composition of Anopheles maculipennis subalpinus H. L. in Shelters of Different Type

For an analysis of the epidemiological role of A. maculipennis in the conditions prevailing in the lowland southeast coastal area of Azerbaidzhan it is essential to find out their biological composition in shelters of different type.

The results of systematic collections of mosquitoes in daytime shelters in the "Pravda" Collective Farm in Girdani are given in Table 2.

The numbers of males and females were expressed as percentages of the total number of mosquitoes. The numbers of females in each Sella stage were expressed as percentages of the total number of females.

TABLE 2

Digestion Stages of Anopheles maculipennis Mg. in Sample Shelters

No.	Type of shelter	Total No. of mosquitoes caught	Including		Stages of females						
			males	females	1	2	3	4	5	6	7
1	Cowshed	8746	18.7	81.7	41.8	0.9	7.3	9.1	8.2	15.0	17.7
2	Storehouse	11552	40.01	59.99	39.4	0.5	7.5	8.8	9.6	19.7	14.5
3	Under verandah of dwelling	898	23.4	76.6	25.2	1.7	14.1	10.0	11.8	22.8	14.4

The composition of the mosquitoes in the shelters was determined by systematic catches made every morning.

On examining the composition of the mosquitoes in sample shelter No. 1 (cowshed) during the season we immediately notice the importance of the cowshed as a place of feeding. Among the mosquitoes caught females (81.7%) predominated markedly over males (18.7%). The majority here consisted of individuals with their stomachs containing blood at intermediate stages of digestion, and females with ripe eggs (58.2%); the percentage of unfed females was relatively high (41.8%); this latter fact can be explained, on the one hand, by the accessibility of the shelters and their proximity to the breeding places [Shipitsina, 1934; Shmeleva, 1935], on the other hand by the fact that in June, when the cattle were taken out of the cowshed, it was transformed from a feeding site to a place of refuge and, finally, to the fact that in the summer-autumn period there was a considerable increase in the numbers of Sella 1 owing to the number of fat females. A great percentage of Sella 1 females was found in the autumn period, this being due to the increased percentage of unfed females made up of diapausing fat females. The number of males increased together with the increased percentage of unfed females.

From August onwards, the composition of the mosquitoes in the cowshed changed. With onset of diapause the proportions of mosquitoes at different stages of the gonotrophic cycle in the shelters was altered and there was an increase in the percentage of fat and unfed females with retarded sexual functions.

In September the percentage of fat females continued to increase, but a definite percentage of females could still be found in intermediate stages of digestion and with developed ovaries, the percentage of males increasing at the same time.

In October the number of fat and unfed females continued to increase; the number of males diminished owing to their dying off and to the absence of new broods. In October, females in the intermediate stages of digestion were still found, indicating that bloodsucking occurred in the shelters in the autumn-winter period (as already mentioned, from September onwards, owing to the cold nights, the cattle were brought into the cowshed from outdoors; it may be assumed in this connection that a certain percentage of the fat production was due to feeding on blood). As regards the rather low percentage of Sella 2, this may be explained as a consequence of the late time of collection and dissection of mosquitoes from the sample shelters, when digestion in a definite percentage of females would have managed to attain the next stage.

Thus, as regards the biological composition of the mosquitoes this shelter can be considered as a feeding site during the spring and autumn periods and as a many-day shelter during the summer.

As regards sample shelter No. 2 (storehouse) we classed this shelter without food as the eustatic type according to its microclimate, since the shelter was fairly well closed with congenial microclimatic conditions and the absence of draft. All these conditions constitute adequate protection for the mosquitoes from the summer heat.

It should be mentioned that in summer and autumn the inhabitants of the house slept on the verandah of the house alongside the sample shelter (storehouse), and the cow spent the night in the yard under a tree. In all

TABLE 3

Table of Digestion Stages (Sella) and Stages of Ovarian Ripening (Christophers) in Anopheles maculipennis subalpinus H. L. in the "Pravda" Collective Farm (June-October, 1956)

Sella	Christophers					
	I	II	III	IV	V	total
1	350	405	10	—	—	765
2	—	17	—	—	—	17
3	3	101	68	5	—	177
4	5	7	83	58	—	153
5	2	4	42	108	—	156
6	4	3	9	233	7	256
7	—	—	—	39	135	174
Altogether	364	537	212	443	142	1698

probability the mosquitoes fed outside on the blood of the people and animals, and then flew into the more protected sites in the shelter, where the digestion continued and was completed in the more congenial microclimatic conditions.

Here there was a predominance of females containing blood at different stages of digestion (47.1%). A considerable percentage also consisted of females with ripe eggs (14.5%) and unfed females (39.4%).

The increase in Sella stage 1, beginning from August, gradually increased and in October reached a maximum. In the autumn period a definite percentage of this number consisted of diapausing fat females. Of the total number of mosquitoes caught during the season 40.01% consisted of males. The peak numbers of males coincided with the peak numbers of mosquitoes in the shelters, while in August, in correlation with the fall in numbers of mosquitoes in the shelters, the number of males diminished also. The great percentage of males in the many-day shelters can be explained by the proximity to the breeding places, the congenial microclimatic conditions of the shelters and, finally, to the seasonal variation in the numbers of the population. Hence, the increase in the percentage of males in the shelters was due to the increase in their total numbers.

Sample shelter No. 2 (storehouse) can be classed as a many-day shelter, according to the biological composition of the mosquitoes (digesting females). The biological composition of the mosquitoes under the verandah of the dwelling house presented a quite different picture; this shelter functioned mainly as a one-day refuge, there being noted, along with a predominant number of males (23.4%) and unfed females (25.2%), females in the intermediate stages of the gonotrophic cycle (60.4%); a considerable number here consisted of females with ripe eggs (14.4%).

6. Gonotrophic Cycle

There are usually three norms of gonotrophic cycle in the A. maculipennis population during the season in the conditions prevailing in the lowland zone of the southeast coastal region of Azerbaidzhan [Beklemishev, Vinogradskaya and Mitrofanova, 1934]; however, in the population investigated there also occur deviations from the norms i.e., there are individuals in which the development of the ovaries lags behind the digestion of the blood and, in addition, we find individuals in which the development of the ovaries is accelerated.

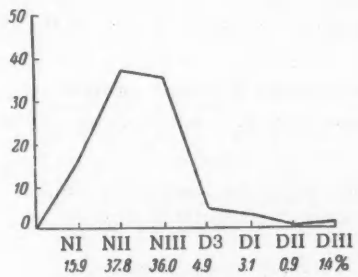

Fig. 2. Curve showing percentages of female Anopheles maculipennis subalpinus H. L. according to their types of gonotrophic cycle. N) Norm, D) dissociation.

The results for June-October, 1956 obtained by dissecting females in the "Pravda" Collective Farm, enabled us to establish the picture of the types of gonotrophic cycle during the summer-autumn period.

The results of the dissections are given in Table 3.

From a comparison of the digestion cycles according to Sella with the cycle of ovarian development according to Christophers we were able to establish that there was a considerable percentage of females (36.0%) in which the development of the ovaries lagged behind the digestion and could be classed under this lag was observed both in June and July, i.e., even before the appearance of fattened females, although in a great number of females the development corresponded to norm II (37.8%) or norm I (15.9%) of the gonotrophic cycle. The curve showing the percentage of females of A. mac.subalpinus H. L. according to their types of gonotrophic cycle in the "Pravda" Collective Farm (June-October, 1956) is given in Fig. 2.

TABLE 4

Percentage Relationships of Types of Gonotrophic Cycle in Females of Anopheles maculipennis subalpinus H. L. in the Months of 1956

Gonotrophic state	Norm			Discordance	Dissociation			Total No. of individuals
	I	II	III		Д I	Д II	Д III	
June	12.2	44.4	41.4	0.3	1.7	—	—	295
July	22.2	34.5	38.4	3.2	1.7	—	—	284
August	13.0	41.7	27.0	13.9	4.4	—	—	115
September	16.4	30.1	24.7	17.8	9.6	1.4	—	73
October	—	—	20.3	—	8.3	25.0	45.8	24

In calculating the percentage relations of the types of gonotrophic cycle we have taken into consideration all the females, except those in the initial stages (combinations 1 I, 1 II, 2 I, 2 II) and females with ripe eggs and no blood in their stomachs (7 V). Thus, Table 3 includes only females which are in a state of digestion, independent of the type of their gonotrophic cycle (gonotrophic concordance or dissociation).

Of the total number of individuals in each month, norm I occurred as a highest percentage in July (22.2%); norm II—in June and August (44.4-34.5%); norm III—in June and July (41.4-38.4%); in all probability, deviations from these norms were due to meteorological factors and the specific microclimatic conditions of the shelters.

The general picture of gonotrophic interrelationships with approach to autumn, as compared with the summer months, is of a different type: in September norm III predominates over norms I and II, the number of dissociated females increasing.

Table 3, which gives the Sella digestion stages and the Christophers stages of ovarian development, shows that there were only 10 females with ovaries in the third stage of development and without blood in their stomachs, 3 of these being found on July 13, two on July 18, one on Aug. 13 and four on Aug. 26, none of these females were fat. In all probability, they were in the early autumn state, at the start of dissociation, and still without fat.

As was shown the first semifat females (stage III) appeared on July 23; thus, gonotrophic dissociation began to appear ten days earlier than the appearance of the first semifat female. The females with gonotrophic dissociation and without fat were then gradually transformed into fat females.

Females with discordance (Table 4) occurred in September; in early spring the normal course of the gonotrophic cycle was disturbed by the effect of low air temperatures in the shelters. In May-June the microclimatic conditions in the shelters approached optimal; in correlation with the approach of the microclimatic conditions to optimal, their number in June was only 0.3%.

Our observations indicate that in autumn, when gonotrophic dissociation occurs in A. mac. subalpinus H.L., indoor infection by malaria in the conditions prevailing in the southeast coastal region of Azerbaidzhan is quite possible, but in the meantime this question is still not settled.

In future research into the epidemiology of malaria in different parts of the above-mentioned zone, we must give attention to this question and take appropriate steps in the conduction of antimalarial measures.

7. Summer-Autumn Phenology of Anopheles maculipennis subalpinus H. L.

According to the data of the Lenkoran Antimalarial Station for the last 15 years, the average date for the start of the exodus of A. maculipennis from their wintering sites is March 22; the earliest exodus was recorded on February 22 (1953), the latest—April 8, 1949. The first stage I larvae appear in Lenkoran on April 28 on the average; the earliest time of their appearance was March 6 (1953), and the latest—May 15, 1947. The appearance of males of the first generation is May 18 on the average. The earliest appearance of males was April 14, (1950), and the latest—May 29 (1945).

TABLE 5

Percentages of Gonadally Active and Diapausing Fat Females among Specimens Dissected in July-October, 1956

	July		August		September		October	
	1-15	15-31	1-15	15-31	1-15	15-30	1-15	15-31
Gonadally active females	6.3	10.4	13.9	5.4	4.5	1.9	1.6	-
Diapausing females	-	0.8	15.2	26.4	37.7	56.05	83.2	97.6

Our first investigations of buildings and waters, carried out in 1956 in Lenkoran region, confirmed these dates approximately: we found stage I A. maculipennis larvae of the first generation in Shagleser on April 7, when the mean twenty-four hourly temperature was 12.6°, and the mean ten-day temperature 10.8°; first-generation males were found on May 10 in Boleda, when the mean twenty-four hourly temperature was 15.2°, and the mean ten-day temperature 14.0°. In the conditions prevailing here the development of the first generation takes place in shallow, well-heated waters; the larvae are not abundant at this time.

As indicated above, the number of mosquitoes in late May-early July 1956 increased very slowly, in spite of the rather congenial mean twenty-four hourly air temperature, and from this we may conclude that a small number of females overwintered. Later, with the start of rice cultivation, the number of mosquitoes in the daily shelters increased markedly.

During June and July only gonadally active mosquitoes were found in the shelters. On analyzing the results obtained from dissections we found that fat appears in the gonadally active mosquitoes earlier than among the diapausing mosquitoes, and fat gonadally active females were mostly found to contain blood at different stages of digestion (Sella 2-6).

The first gonadally active fattening females appeared on July 3, 1956 (Sella 4, Christophers III, 4-IV, 6-IV), earlier than diapausing females; in the first half of July we found 6.3% fat gonadally active females in the shelters.

The first diapausing fat females of A. mac. subalpinus H. L. were found in the storehouse on July 23, 1956, when the mean twenty-four hourly air temperature outside was 23.9° and the mean ten-day temperature was 25.8°.

Later the number of fat females, gonadally active and diapausing, increased. The percentage of fat gonadally active females reached a maximum in the first half of August (13.9%) and then their percentage fell considerably, reaching a minimum (1.9%) in the first half of October, while the percentage of fat diapausing females increased sharply, reaching 97.6% in the second half of October (Table 5). The October temperature during the years of observation varied between 9.2 and 18.4°, the mean over several years being 16.2°.

In determining the percentage of fat females among those dissected we counted only fat ones in stages III-IV, fat ones in stage II being considered as fattened within the limits of the summer norm.

As indicated, we recorded initial stages of fattening as early as late June, but really fat females did not occur until the 2nd ten days of August; the fattening process progressed rapidly with approach to hibernation.

Among the mosquitoes dissected during season 1956 we determined the percentage of females at fatness stages III-IV (Table 6).

The physiological state of the mosquitoes depends on many factors, particularly on temperature. In the 3rd ten days of July 11.6% of the females were in Christophers stage I, 0.8% in fatness stage III. From Table 7, which gives the data of phenological observations in the "Pravda" Collective Farm in Girdani in 1956, we see that the percentage of diapausing fat females begins to increase in the first ten days of August, while the percentage of nonfat females falls and in October constitutes only an insignificant portion of the females dissected.

TABLE 6

Percentage Fattening among Dissected Females of Anopheles maculipennis subalpinus H.L. in Ten-Day Periods of 1956

Months	Ten-day period	No. of females dissected	In fatness stages III-IV (in %)	Including fatness stage IV (in %)
July	3	129	0.8	—
August	1	93	12.9	1.1
	2	155	20.6	7.7
	3	142	30.3	12.7
September	1	104	33.7	13.5
	2	97	49.5	29.9
	3	110	57.3	40.9
October	1	84	79.7	57.1
	2	78	93.6	67.9
	3	45	97.8	91.1

As Table 7 shows, the numbers of females in fatness stage II in the shelters gives a slight upward jump in the 3rd ten days of September. Probably these are newly emerged autumn-generation females which require additional food for complete fattening.

The physiological state of the mosquitoes also depends on the microclimatic conditions in the different indoor shelters (Fig. 3).

We see from this figure that diapausing fat females appeared first in the shelters without food (storehouse); they did not appear in shelters with food (cowshed) until 10 days later. Since fattening of A. mac. subalpinus H. L. is due to feeding on blood we would have expected the reverse. This may be explained in the following way: owing to the absence of food in the cowshed it constituted a many-day shelter and not a feeding site; on the other hand, this sequence was associated with the microclimatic conditions of the shelters. In all probability the mosquitoes fed outside the sample shelters and flew into them to digest the blood.

Among the diapausing fat females there was a considerable percentage of females containing blood. Females with blood were found right up to the end of October (up to the departure of the expedition). An analysis

TABLE 7

Indices of Physiological State of Female Anopheles maculipennis subalpinus H. L. Caught in Sample Shelters on the "Pravda" Collective Farm in the Lenkoran District in the Summer-Autumn Period of 1956

Months	Ten-day period	Mean ten-day temperature	No. of females dissected	Percentages											
				sella				christophers				fatness			
				1	2	3–6	7	I	II	III–IV	V	I	II	III	IV
July	3	23.4°	129	27.9	—	65.1	7.0	11.6	27.9	55.1	5.4	99.2	—	0.8	—
August	1	25.8	93	35.5	—	44.1	20.4	20.4	22.6	38.7	18.3	86.0	1.1	11.8	1.1
	2	22.8	155	56.8	—	16.8	26.4	20.0	36.1	24.5	19.4	77.5	1.9	12.9	7.7
	3	24.9	142	62.0	—	19.0	19.0	15.5	43.7	23.2	17.6	65.5	4.2	17.6	12.7
September	1	21.3	104	68.3	—	20.2	11.5	15.4	52.9	24.0	7.7	56.7	9.6	20.2	13.5
	2	20.5	97	69.1	—	20.6	10.3	4.1	69.1	23.7	3.1	44.3	6.2	19.6	29.9
	3	14.4	110	80.9	—	17.3	1.8	22.7	64.6	12.7	—	32.7	10.0	16.4	40.9
October	1	17.5	84	82.1	—	17.9	—	85.7	9.5	4.8	—	13.2	7.1	22.6	57.1
	2	14.3	78	92.3	—	7.7	—	96.2	3.8	—	—	—	6.4	25.7	67.9
	3	13.1	45	93.3	—	6.7	—	100.0	—	—	—	—	2.2	6.7	91.1

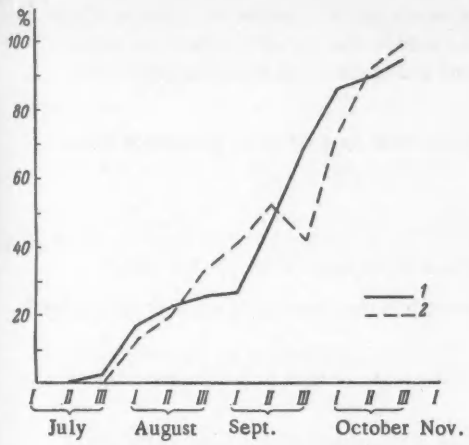

Fig. 3. Curve showing change in percentage of fat females among dissected Anopheles maculipennis subalpinus H.L. in ten-day periods of 1956 in the "Pravda" Collective Farm. 1) Shelters without food; 2) shelter with food.

of the individuals comprising the fat females showed that a considerable number of mosquitoes became fat in the state of discordance as a result of autumn feeding on blood; this circumstance can lead to a prolongation of the period in which they can transmit malaria.

The presence of cases of complete fattening in September during the normal course of the gonotrophic cycle (Table 7) indicates that a certain proportion of the population in these conditions enters the winter diapause after egg laying has taken place. This reveals that in the conditions here it is quite possible for females which have passed through a period of sexual activity to enter a state of diapause.

The migration of mosquitoes to winter sites begins almost at the same time as the appearance of diapausing fat females and lasts until November. The majority of females migrating to winter sites consist of young females which have not laid eggs.

Like A. mac. atroparvus Thiel, the females of A. mac. subalpinus H. L. are in a state of gonotrophic dissociation (they continue to feed on blood), probably beginning in autumn and lasting throughout the winter, and as a result indoor transmission of infection is possible in the conditions prevailing in the lowland zone of the southeast coastal region of Azerbaidzhan, but this has still not been investigated in these conditions.

SUMMARY

From the foregoing account we can make the following summary:

1) A. mac. subalpinus H.L. is a characteristic representative of the malarial mosquitoes of the lowland landscape of the southeast coastal region of Azerbaidzhan and is the main malaria vector in this zone.

2) From an analysis of the results of our observations on the ecology of A. mac. subalpinus H.L. it can be stated that there is full agreement with the findings of other authors; some deviations which were observed are in all probability due to the specific microclimatic conditions of the daytime shelters and which are dependent on local conditions.

3) The gonotrophic cycle in A. mac. subalpinus H.L. in the locality studied mainly proceeds according to norms II and III .

4) Characteristic for A. mac. subalpinus H.L. is the southern type of seasonal variation in numbers, forming a two-peak curve with a dip during the period of highest summer temperatures. However, owing to the presence of large breeding areas for the mosquitoes there is also found a one-peak curve of population variation (in the rice-growing zone).

5) The overwintered mosquitoes and mosquitoes of generation I have no epidemiological significance in view of their small numbers; moreover, according to the results of several years' observations, temperatures above 15° in the locality studied do not set in until May and prevail almost to the end of October (see table in section "Natural Conditions of Locality and Climate"). Sporogony is not possible until May, but when the May temperatures are low it takes more than 30 days on the average; in such cases the chances of the mosquitoes surviving are slight. Only from June can the mosquitoes constitute a danger as regards malaria transmission.

6) According to the results of dissections, a few diapausing fat females of A. mac. subalpinus H.L. begin to appear in early August; they start to appear in large numbers in the 2nd ten days of September.

7) Autumn fattening accompanied by blood feeding considerably prolongs the period of possible malaria transmission by A. mac. subalpinus H.L.

8) With the occurrence of gonotrophic dissociation in A. mac. subalpinus H.L. indoor transmission of malaria is possible in the autumn-winter period. This has not yet been clarified, but it should be borne in mind in the study of the epidemiology of malaria in different parts of the zone and in the conduction of antimalarial measures.

9) In the organization of antimalarial measures, special attention must be paid to the prevention of the spring-summer increase of the mosquito population.

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ON THE MIGRATIONS OF BLACK FLY LARVAE

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By migrations of larvae we mean their active or passive movements in the river over fairly considerable distances.

Observations have shown that larval migrations can significantly alter the numbers of black flies emerging from a particular section of the river. Hence it is important to establish the causes of migration both for revealing individual aspects of the biology of black flies, as well as for solving some questions of their control and predicting the size of the emerging population.

Despite this, the phenomenon of migration has been poorly studied until recently. Moreover, for a long time there has been no unified opinion on the ability of larvae to migrate in the river. The belief that larvae do not leave the substrate selected by them [Dorogostaiskii, Rubtsov and Vlasenko, 1935] has not been borne out by observations. That larvae are capable of migrations and that these take place is no longer in doubt. In 1956 we especially determined the density of larvae, and showed that it was only a little greater than that of water, being equal to 1.079 g/cm^3. Hence when larvae become detached from the substrate they do not sink to the bottom but are able to maintain themselves in midwater. Moreover, the thread on which they float downstream breaks away from the substrate and considerably increases the buoyancy of the larvae.

Our own and foriegn literature on larval migrations, as far as we know, contains only fragmentary information, which mainly confirms the ability of larvae to migrate in the river [Friederichs, 1919; Petersen, 1924; Rezvoi, 1930; Stukolkina, 1939; Terteryan, 1951, Zachar, 1951], and only three works [Rubtsov, 1940; Radzivilovskaya, 1950; Usova, 1953] contain more detailed results of special studies of this question.

The first attempt to discover the causes and patterns of migration was made by Rubtsov [1940]. Daily counts over two months on sampling areas (stakes, pieces of timber, leaves of bank vegetation trailing in the water) led the author to conclude that daily, seasonal, periodic and other migrations occurred, and the causes of these were various changes in the water temperature, oxygen content, nature of illumination, current speed and lastly, various biotic factors—fish, caddis grubs and larvae of other insects.

Radzivilovskaya [1950] studied the question of migration in order to discover the conditions suitable for the settlement of larvae. By applying the "comb" method she had devised for a quantitative survey of settling larvae [1950], Radzivilovskaya showed that the settlement of larvae took place mainly at night, that they migrated by day, and that the reason for the varying intensity of diurnal migrations, both at the surface and at depth 25 cm (on the bottom) was the change in the light conditions. Among the general factors causing migration Radzivilovskaya mentioned, especially, changes of level and the concomitant disturbance of the general regime of the river, i.e., changes in transparency, water temperature and current speed.

Usova [1953], who studied the nature of the diurnal and spring-autumn migrations in the rivers of Karelia, came to the same conclusions as Radzivilovskaya (at first Radzivilovskaya's method of combs was used, and then the combs were replaced by tiles).

Thus, these studies established a causal relation between the migration of larvae and changes in environmental conditions. What exactly was the relation between them was left unexplained. This question was the basic one in the present work.

TABLE 1

Results of Counts of Migrating Larvae in a Branch of the R. Angara and a Tributary of It

Level			Branch				Tributary				Date when twigs were set	
date	Bratsk	Padun	total No.		mean No. per 1 m		total No.		mean No. per 1 m		in branch	in tributary
			larvae	pupae	larvae	larvae and pupae	larvae	pupae	larvae	larvae and pupae		
June												
16	76	166	—	—	—	—	—	—	—	—	—	—
17	78	168	—	—	—	—	—	—	—	—	—	—
18	84	172	—	—	—	—	—	—	—	—	—	—
19	102	184	—	—	—	—	—	—	—	—	—	—
20	110	191	—	—	—	—	—	—	—	—	—	—
21	122	198	511	7	154	156	—	—	—	—	—	—
22	135	210	—	—	—	—	—	—	—	—	19 VI	—
23	131	208	1514	73	115	120	146	4	65	68	19 VI	21 VI
24	118	200	—	—	—	—	—	—	—	—	—	—
25	108	192	—	—	—	—	—	—	—	—	—	—
26	100	187	888	354	69	96	—	—	—	—	19 VI	—
27	91	179	—	—	—	—	156	34	56	68	—	21 VI
28	91	178	—	—	—	—	—	—	—	—	—	—
29	97	184	271	5	53	55	—	—	—	—	—	—
30	116	191	—	—	—	—	—	—	—	—	19 VI	—
July												
1	178	236	—	—	—	—	—	—	—	—	—	—
2	196	255	1272	145	173	192	—	—	—	—	—	—
3	172	241	—	—	—	—	—	—	—	—	19 VI	—
4	172	231	448	130	62	80	415	1183	57	220	19 VI	21 VI
5	203	260	—	—	—	—	—	—	—	—	—	—
6	182	250	122	—	36	36	—	—	—	—	4 VII	—
7	150	228	45	109	14	48	—	—	—	—	4 VII	—
8	130	209	—	—	—	—	4	215	2	126	—	21 VI
9	118	199	18	2	4	5	—	—	—	—	4 VII	—
10	112	193	—	—	—	—	—	—	—	—	—	—
11	—	193	—	—	—	—	—	—	—	—	—	—
12	—	195	22	51	3	9	—	—	—	—	19 VI	—

Out observations were made in the middle course of the R. Angara (above Padun Rapids) and in its tributaries—the rivers Vikhorevka and Zyaba. The observations showed that one of the possible results of a rise of water level was a considerable redistribution of the larvae in the river. For instance, on June 9, 1955, when the water was low several "trap" pine twigs were laid on the bottom of the R. Vikhorevka in places where larvae were absent. A week later, i.e., June 16, when the level had risen and the current speed had increased from 0.64 to 1.28 m/sec, the larvae disappeared from spots which had previously been abundantly colonized, and on the trap twigs we found large numbers of larvae of the same species (Gnus jacuticum Rubz., Simulium tuberosum Lundstr., S. subvariegatum Dor. et. Rubz., S. reptans var. galeratum Edw., Boophthora erythrocephala De Geer).

In the R. Zyaba, from June 16, 1956, onwards, we found at first larvae, and then pupae of only two species — Eusimilium latipes Mg. and E. bicorne Dor. et Rub — but these were present in very large numbers. On July 13, when the Zyaba had risen, the larvae and pupae of these species were very rarely encountered, and on the heaps of vegetation and sticks there appeared many full-grown larvae of Simulium tuberosum Lundstr., which in all probability had been carried down from the upper reaches of the river.

Such a redistribution of species in the R. Angara was observed several times. The larvae could migrate over great distances, and as a result a considerable proportion of the larval population might be destroyed. Such an event was noted in the Angara in 1955, when a sudden rise in the water level caused the migration and destruction of large numbers of larvae.

From June 19 to July 12 in 1956 we made regular counts of the numbers of migrating larvae. The counts were made a little above PadunRapids in one of the branches of the Angara and in a small tributary of it. In the Angara branch, which was about 50-60 m wide and 3.5-4 m deep we stretched a wire under the surface from one bank to the other. On this wire pine twigs were attached 70-100 cm apart (the average length of the twigs was 25.30 cm). A similar wire was fixed across the tributary, which was about 10-12 m broad and 1.5-2 m deep. Counts were made in the branch at intervals of 2 days, and in the tributary at intervals of 3-4 days. In order to determine the numbers of migrating larvae and their species composition on the particular days, twigs were removed from the wire in each section, i.e., at the sides of the right and left banks and in the center, and were replaced by 2-3 new twigs with tags attached to them, so as to distinguish them from previously attached ones. Each time that twigs were removed from the wire we measured the current speed (by a Glushkov tachometer) and water temperature. At each count we removed 1-2 twigs, those from each section of the branch, i.e., near the banks and in the middle, being removed and analyzed separately. In the tributary, since the same conditions prevailed at every point in it, such a division into sections was not made. The twigs were removed to the laboratory and washed in enameled basins; the needles, after careful inspection, were torn off and the total length of the twigs was measured. Then the larvae and pupae were identified to species, and their total number and density per 1 m of substrate in each section were determined. In addition, the larvae in each sample were separated according to their stages. The results of the counts in the branch and the tributary, and the data showing the variation in water level during the whole period of the observations are given in Table 1.

The changes of current speed and turbidity during this period were a direct result of changes in water level. Hence the changes in this latter factor must be considered as the most important. Our figure gives a day-to-day comparison changes of water level during these days.

As we can see from the figure and Table 1, the most rapid rises of water took place between June 19 and 21, and between June 30 and July 2. On these days we also recorded the highest density of larvae on the trap twigs: 154 ind. per 1 m on June 21, 173 ind. per 1 m on July 2. A further rise of level did not increase the rate of migration—on June 23 the mean number of larvae per 1 m of substrate had fallen to 115. The numbers of migrating larvae continued to fall right up until July 2, when they again sharply increased with a rapid rise of level. The fall in level in the following 2 days was again accompanied by a decrease in the number of migrating larvae to 62 ind. per 1 m on the average, i.e., to less than a half of their number in the preceding count.

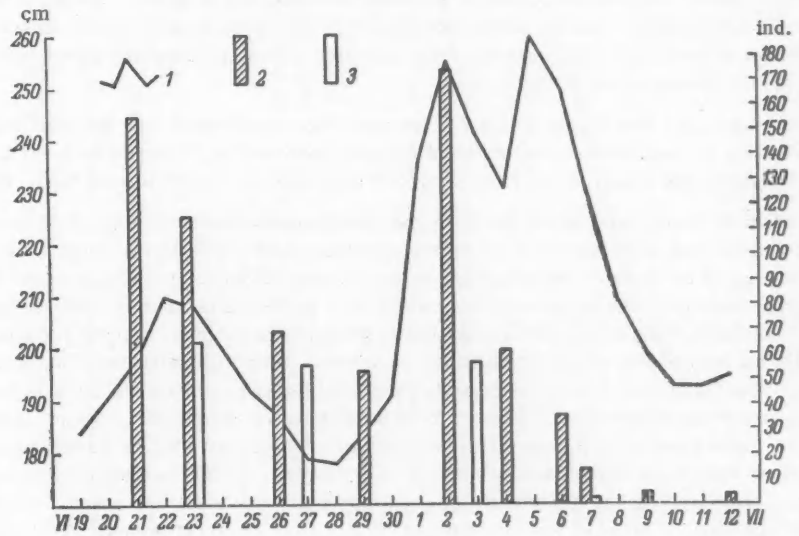

Fig. Changes of level (1) in R. Angara and mean numbers of larvae migrating in branch (2) and tributary (3).

On July 4 new twigs were attached to the wire, and these were removed on July 6, 7, and 9. The numbers of larvae settling on them showed that there had been less migration, despite the further rise in level up to a peak during these days. The last twigs from those attached on June 19 were removed on July 12. The drop in level and the concomitant decrease in turbidity and reduction of current speed led to a fall in the larval density to 3 per 1 m. The great numbers of larvae during the drop in level places where they usually occurred (the rapids, right and left bank) and the very small numbers of larvae on the trap twigs indicated that there was no migration on these days. These results show that when the level drops and normal conditions are restored the numbers of settled larvae exceed the numbers migrating.

From the foregoing the relation between the intensity of migration and the changes of level can be represented in the following way. First, the intensity of migration depends on the rapidity of rise of the water level. Secondly, the greatest numbers of migrating larvae are found at the very beginning of the rise in level. A further gradual rise does not increase the numbers of migrating larvae, since by this time the larvae have managed to find suitable places for resettlement where there is less silting of the substrate. The intensity of the migration is not governed by the absolute rise of level, but by the rapidity of rise and the accompanying increase in turbidity. According to Usova's [1953] observations, a marked increase in turbidity causes almost half the total number of larvae to break away from the substrate in the first 10 minutes, while less than $\frac{1}{4}$ of those remaining after the 10-minute count break away in the subsequent 20 minutes.

A comparison of the species from simultaneous samples from trap twigs in the branch and from other spots above Padun Rapids showed that the migrating larvae consisted of all the species present in the river at the time. Among the species migrating in the branch and tributary the dominant one was that one which was most abundant in the river at the time (Table 2). For instance, from mid-June to the end of the month the most numerous species was Simulium reptans var. galeratum Edw., which predominated in the samples from the trap wire and also from other parts of the river.

A count made on one day (July 6) in the branch and on a shoal a little above it showed that the ratios of the black fly species were different in them. In the branch Byssodon transiens Rubz. (35.4% of the larvae) and S. reptans var. galeratum Edw. (33.3% of the larvae) were dominant. On the shoal the most numerous were S. reptans var. galeratum Edw. (36.2% of larvae and 75.4% of pupae) and Wilhelmia equina L. (36.7% of larvae, 4.6% of pupae), while B. transiens Rubz. comprised 18.9% of the larvae and 3% of the pupae. The contribution of Gnus cholodkovskii Rubz. in the branch was 12.5%, but on the shoal it was only 0.2%. Though S. subvariegatum Dor. et Rubz. and B. erythrocephala De Geer occurred on the shoal they were few in number (2% and 0.4%), and in the branch these species were absent. This comparison indicates that the species composition of larvae migrating into the branch was not determined by the adjacent richly populated parts and, hence, the larvae must have been carried into the branch from a greater distance.

We cannot compare the migrational abilities of the individual species since they are correlated with features of the distribution of the different larval stages of the individual species. It should be noted that above the rapids, where the counts were made, the majority of species developed in more or less the same conditions.

When we examine the material we are struck by the obvious predominance of stage IV larvae. The large numbers of pupae on the trap twigs, amounting in certain counts to 71.8%, indicate that stage IV larvae had migrated downstream settled on the twigs, and managed to pupate; stage III larvae occurred in somewhat smaller numbers and their percentage in the samples did not exceed 40.9-44.2%; the numbers of migrating stage II larvae were very small (the ratios of the stages of migrating larvae are given in Table 3). Only in two counts, June 21 and July 6, did the numbers of migrating stage II larvae constitute a fairly high percentage (33.5% on June 21, 25.4% on July 6). These counts were made on days when the level had risen. Hence the increase in the numbers of stage II larvae on the trap twigs can be attributed to their being carried downstream. Stage I larvae were not found at all in the counts from the trap twigs. This fact, and also the fact that they are usually found on plants and stones in shallow water close to the bank, at the sites of egg laying, permit the assumption that stage I larvae do not migrate and remain at the site of hatching until they molt. Of the total numbers of larvae migrating in the branch, 65% consisted of stage IV larvae and pupae, 32% of stage III larvae and only 3% of stage II larvae. Observations on different parts of the Angara, as well as in the Vikhorevka and Zyaba, gave the same results: the greatest percentage of migrating larvae were stage IV larvae, the lowest were stage II larvae.

In Rubtsov's [1940] opinion, age differences in the intensity of migration are insignificant. On the grounds that newborn larvae and larvae ready for pupation occurred on the sampling areas relatively rarely, the author

TABLE 2

Proportions of Species of Larvae and Pupae (in %) in Different Parts of Angara above Padun Rapids

Species	Angara branch										Tributary				Shoal above trap wire		P'yanyi byk		Left bank of Angara	Right bank of Angara
	21 VI	23 VI	26 VI	29 VI	2 VII	4 VII	6 VII	7 VII	9 VII	12 VII	23 VI	27 VI	3 VII	7 VII	18 VI	6 VII	20 VI	25 VI	13 VI	10 VII
S. reptans var. *galeratum* Edw.	46.2 57.1	54.2 54.8	66.2 61.0	54.0 60.0	43.5 61.2	39.6 67.0	33.3 0.0	37.0 68.0	27.7 100.0 1 specimen	31.0 84.0	49.2 25.0	45.3 40.0	36.1 74.7	0.0 80.0	77.4 82.0	36.2 75.4	50.3 83.0	47.5 59.5	60.9 100	—
B. transiens Rubz.	43.1 42.9	38.1 43.8	28.0 33.0	35.7 40.0	46.0 35.2	51.0 29.2	35.4 0.0	58.0 25.5	61.1 0.0	50.0 12.0	35.3 75.0	53.0 53.0	56.3 50.6	(3 шт.) 100 18.1	13.4 18.0	18.9 3.0	16.2 13.0	9.9 11.5	34.1 0.0	—
S. morsitans Edw.	6.6 0.0	1.8 0.0	1.7 1.4	2.3 0.0	1.0 0.0	0.7 0.0	1.0 0.0	0.0 4.5	—	6.5 0.0	9.8 0.0	0.7 0.0	1 1.2	—	8.3 0.0	7.5 15.0	33.3 4.0	42.0 29.0	4.5 0.0	1.3 5.0
G. cholodkovskii Rubz.	4.1 0.0	4.9 0.0	2.9 1.4	7.0 0.0	6.5 1.3	5.8 3.0	12.5 0.0	—	5.6 0.0	12.5 4.0	3.9 0.0	—	1.2 0.0	0.0 1·3	0.9 0.0	0.2 0.0	0.2 0.0	0.3 0.0	0.5 0.0	—
S. subvariegatum Rubz.	—	1.0 1.4	0.2 3.2	—	0.0 1.3	0.0 0.8	—	—	—	—	2.0 0.0	0.0 7.0	0.2 0.0	—	—	0.0 2.0	—	—	—	—
W. equina L.	—	—	1.0 0.0	—	3.0 0.0	2.9 0.0	17.8 0.0	5.0 0.0	5.6 0.0	—	—	0.7 0.0	5.0 0.0	0.0 0.6	—	36.7 4.6	—	—	—	1.3 40.0
B. erythrocephala Deg.	—	—	—	—	—	—	—	0.0 0.9	—	—	—	—	0.2 1.2	—	—	0.4 0.0	—	0.3 0.0	—	97.4 55.0

Note: The numerator gives figures for larvae, the denominator for pupae.

TABLE 3

Proportions of Stages of Migrating Larvae

Date	Angara branch										Tributary									
	larvae						pupae		larvae IV + pupae		larvae						pupae		larvae IV + pupae	
	II		III		IV						II		III		IV					
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%
21 VI	174	33.6	156	30.1	181	35.0	7	1.3	188	36.4	—	—	—	—	—	—	—	—	—	—
23 VI	58	3.7	550	34.6	906	57.1	73	4.6	979	61.7	4	2.7	60	40.0	82	54.6	4	2.7	86	57.3
26 VI	65	4.9	316	23.5	607	45.2	354	26.4	961	71.6	—	—	—	—	—	—	—	—	—	—
27 VI	—	—	—	—	—	—	—	—	—	—	8	42	50	26.3	98	51.5	34	18.0	132	69.5
29 VI	35	12.6	113	40.9	123	44.5	5	2.0	128	46.5	—	—	—	—	—	—	—	—	—	—
2 VII	186	13.1	438	30.8	648	45.7	145	10.4	793	56.1	—	—	—	—	—	—	—	—	—	—
3 VII	—	—	—	—	—	—	—	—	—	—	3	0.2	102	64.0	310	19.4	1183	74.0	1493	93.4
4 VII	15	2.6	165	28.5	268	46.3	130	22.6	398	68.9	—	—	—	—	—	—	—	—	—	—
6 VII	31	25.4	54	44.2	37	30.4	0	0.0	37	30.4	—	—	—	—	—	—	—	—	—	—
7 VII	4	2.6	9	5.8	32	20.8	109	71.8	141	92.6	0	0.0	3	1.4	1	0.5	215	98.1	216	98.6
9 VII	0	0.0	3	15.0	15	75.0	2	10.0	17	85.0	—	—	—	—	—	—	—	—	—	—
12 VII	0	0.0	15	20.6	7	9.6	51	69.8	58	79.4	—	—	—	—	—	—	—	—	—	—

TABLE 4

Distribution of Species in Different Sections of R. Angara Branch

Species	On right bank		In center of branch		On left bank	
	abs.	%	abs.	%	abs.	%
S. reptans var. *galeratum* Edw.	964	38.7	769	30.8	759	30.5
B. transiens Rubz.	570	32.2	642	36.3	557	31.5
S. morsitans Edw.	29	45.0	11	17.0	25	38.0
G. cholodkovskii Rubz.	66	31.2	105	49.8	40	19.0
S. subvariegatum Rubz.	10	27.3	10	27.0	17	46.0
W. equina L.	26	43.0	24	40.0	10	16.7
B. erythrocephala Deg.	Solitary specimens		—	—	—	—

concluded that at these stages the larvae possessed a lesser migrational ability. Usova [1953] also held the same opinion. According to her results, the most frequent among the migrating larvae were stages II and III, and stage I larvae and those ready to pupate occurred more rarely. Since these two authors confined themselves to an exposition of their views on this question, without confirming them by factual data, a discussion of their results is impossible.

According to Radzivilovskaya's data [1950] 80 to 95% of the larvae settling on the sampling combs consisted of larvae of the first two stages and only 20% consisted of stage III and IV larvae; the pupae in the counts did not constitute more than 1%.

The apparent contradiction between our results and those obtained by Radzivilovskaya may be explained in the following way. Radzivilovskaya conducted counts in order to discover the conditions favorable for the settlement of larvae, and for this purpose she selected a site where there was a greater settlement of larvae than in other parts of the river. Thus for these sites she chose an area where optimal conditions were known to occur. These conditions were most congenial for larvae of the younger (I and II) stages. Stage III and IV larvae passed through these sampling areas without settling on them. For our counts the trap-twig wire was set to catch larvae which were carried by the current in the surface layers. The larvae readily settled on the pine twigs, which constituted suitable sites. Hence the results of our counts more truly reflect the actual proportions of the migrating stages. These proportions are such that we can assume that the later the stage of the larvae, the greater is their migrational ability.

The greater migrational ability of stage III and IV larvae may be attributed first, to an increase with age in the sensitivity of larvae to their environmental conditions and, secondly, to the fact that they require different conditions for development in comparison with the younger stages. Stage I and II larvae develop in more or less the same conditions. These stages are usually found in shallow water, in areas with low current speed. Stage III larvae are invariably found at greater depths, in parts of the river where the current speed is greater for the species. In these parts we often find young stage IV larvae, but they migrate into calmer parts of the river for pupation. For instance, larvae of G. cholodkovskii Rubz. find the most congenial conditions for development in the rapids of the Angara, while for pupation they migrate into the calmer parts below the rapids.

A comparison of the numbers of migrating larvae in different sections of the branch showed that the greater number (37%) migrated along the right bank. In the center of the river it was a little less and on the left bank it was 30%. The higher numbers of larvae along the right bank cannot be explained by the predominance of any one particular species here, since the greater number of almost all the species (Table 4) migrated along the right bank. The exceptions were G. cholodkovskii Rubz. and B. transiens Rubz., which prefer higher current speeds and in view of this predominate in the center of the river, and S. subvariegatum Dor. et Rubz., the larvae of which are more often found on the left bank of the river.

The great number of larvae on the right bank is correlated with the fact that the branch is so placed in relation to the direction of the main river that the main mass of water flowing into the branch, and the larvae along with the water, passes along the right bank. This means that the numbers of migrating larvae are greater in the main stream of water, and depend on the numbers of larvae in the area from which they are carried.

TABLE 5

Proportions of Stages of Migrating Larvae in Each Section

State	Right bank		Center of branch		Left bank	
	abs.	%	abs.	%	abs.	%
IV	1349	40.0	1119	31.0	1041	29.0
III	512	30.0	639	40.0	512	30.0
II	110	30.0	107	28.0	157	42.0

We see from Table 5, which shows the proportions of the stages of migrating larvae in each section, that the majority of stage IV larvae migrate along the right bank of the branch and that their numbers decrease toward the left bank.

The distribution of the stage of migrating larvae in the different sections corresponds to the demands of each stage on the environmental conditions. The majority of stage IV larvae settled near the right bank, where the current speed is 0.66 m/sec and represents the best conditions for the majority of species. Stage III larvae settled mainly in the center of the river—in the section of the branch with the fastest current (0.78 m/sec)—and were distributed in equal numbers along the banks. On the left bank of the branch, where the current speed is 0.7 m/sec, there was a predominance of stage II larvae, constituting 42% of the total number of migrating larvae of this stage.

It is of interest to note that the migrational activity of the larvae increases before molting, when they are most sensitive to various disturbances in the normal conditions of existence. For instance, the larvae of all stages present in the count samples were either at the very beginning of the stage, i.e., just after molting, or at its very end; of the stage IV larvae, the overwhelming majority had well-developed respiratory filaments.

The behavior of the larvae in relation to sharp changes of level reveals new methods of combating black flies in the preimaginal phases of development. Radzivilovskaya [1950] noted that sharp changes of level in the R. Suputinka (south Ussurian taiga), resulting from the operation of locks designed for timberrafting, rid the river of the aquatic phases of black flies not only over the stretch where the locks were in operation (3.5 km), but also over a considerably greater distance (to 6 km downstream). In the following year, when the locks were not in operation, an examination of the river revealed large numbers of larvae and pupae.

In 1952 Usova introduced the operation of locks on a stream with the aim of reducing the larval population by sudden changes of level. The observations showed that with frequent alternation of high and low level only a few larvae managed to complete their development, and the black flies emerging from them comprised a very small percentage of bloodsucking insects.

On the Angara, at the site of construction of the Bratsk Hydroelectric Station, the numbers of emerging flies could be reduced by sharp changes of level during the construction of the dam, and by artificially promoting turbulence of the water over great distances by the use of suction dredges.

SUMMARY

1 Migrations of black fly larvae result from disturbances in the normal conditions of existence—increased turbidity and current speed, which are primarily due to changes of level. Hence changes in the water level can be considered as the main cause of seasonal migrations.

2) The numbers of migrating larvae depend on the rapidity of the rise in level; the more rapid and marked the rise, the more larvae migrate. The greatest numbers of migrating larvae are observed at the very beginning of a rapid rise of level. A further rise of level not only produces no increase in the number of migrating larvae but, on the contrary, reduces their number.

3) Larvae of all the species present in the river at the time migrate, and the dominant one in the migration is the one most numerous in the river at the time.

4) The migrational ability of the larvae increases with age: commonest among the migrating larvae are stage IV larvae, and many of these are on the point of pupation; stage III larvae are a little less numerous, stage II larvae are found in still smaller numbers and stage I larvae are completely absent. There is an increase in migrational activity just before molting, when the larvae are most sensitive to various disturbances in the normal conditions of existence.

5) In view of the behavior of the larvae toward sharp disturbances of the river regime, we are able to suggest new methods of controlling black flies in the aquatic phases of development.

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THE FAUNA AND ECOLOGY OF PSOCOPTERA IN THE MOSCOW AND RYAZAN REGIONS

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In our country the study of Psocoptera is at the stage of discovering the species present in a local fauna. Three faunal lists have been published so far on the Psocoptera of European Russia (Ul'yanin, 1869; Yakobson and Bianki, 1905. Zavarzin, 1906) and include about 50 species, while faunal lists of Psocoptera of the Sukhumi, Batum, and Sochi Botanical Gardens and of the Latvian SSR have been published, with the description of two new species (Danks, 1950a, 1950b, 1950c, 1955). The biology of one species—Trogium pulsatorium L.—has been touched upon with experimental observations. (Solov'ev, 1924).

My ecological and faunistic observations, the results of which provide the material for the present paper, were carried out from June to August, 1954, in the environs of the agrobiological station in the Chashnikovo-Khimkin district of the Moscow region, in September 1955 in the area of the Zvenigorod Biological Station in the Moscow region, and from June to August, 1955, in the Oksk State Preserve in the Ryazan region.

Faunal investigations were carried out at least twice a week in various stations— in mixed and spruce forest (Moscow and Ryazan regions), in birch, oak, linden, and pine forests (Ryazan region), and in willow growth along the shores of the Klyaz'ma and Pra rivers. The Psocoptera were collected by means of beating branches of trees and bushes, using a net. Nests and litter were collected by hand with the aid of a hand lens. In order to study their biology experimentally, the following species were raised under laboratory conditions: Psococerastes gibbosus, Metylophorus nebulosus, Euclismia conspurcata, Stenopsocus immaculatus, Caecilius flavidus, C. fuscopterus and Lachesilla quercus. For rearing Psocoptera test tubes are perfectly suitable containers when kept in a desiccator at a mean temperature of 25°C and a constant relative humidity of 75%. The insects fed on growths of green Protococcales algae and also on parasitic fungi developing on the fresh leaves of linden and oak (the usual habitat substrate of Psocoptera).

Of the 30 species recorded from the Moscow and Ryazan regions (Table 1), Neopsocopsis hirticornis, N. pyrenaicus, Reuterella helvimacula and Bertkauia lucifuga, from the Ryazan region, are recorded for the first time from the USSR. Ectopsocus sp. appears to be a new species. The earliest species to appear in the Moscow region are Euclisma conspurcata, Amphigerontia bifasciata, Stenopsocus immaculatus, Caecilius flavidus, Lachesilla pedicularia, Peripsocus phaeopterus, Mesopsocus unipunctatus, appearing in the second or last third of June, while in the Ryazan region Peripsocus phaeopterus and Mesopsocus unipunctatus are found during the second third of June. The most frequently encountered species in these regions are Psococerastes gibbosus, Metylophorus nebulosus, Euclismia conspurcata, Amphigerontia bifasciata, Copostigma contrarium, Caecilius flavidus, C. fuscopterus, Lachesilla pedicularia, L. quercus, Peripsocus phaeopterus, Ectopsocus sp., Mesopsocus unipunctatus, Holoneura laticeps. The rarest species are Loensia variegata, Neopsocopsis hirticormis, N. pyrenaicus, Stenopsocus stigmaticus, Caecilius piceus, C. gynapterus, Bertkauia lucifuga, Philotarsus flaviceps.

Psocoptera occur on the trunk branches, and leaves of various trees and bushes (Table 2). They may also be found among fallen leaves, under stones, occasionally in the nests of insects and birds. We found the comparatively rare Lachesilla pedicularia in wasps' nests, while Liposcelis silvarum was rather frequently encountered in the nests of birds and, in very large numbers, in chicken houses. The selection of habitat sites by Psocoptera depends to a large extent on the presence of food, the humidity of the air, and the inhabited substrate. Psocoptera feed on

TABLE 1

Species of Psocoptera Found in the Moscow and Ryazan Regions

Species	Moscow region	Ryazan region
Fam. *Psocidae*		
1. *Psococerastis gibbosus* Sulz.	14 VII—11 VIII 54	20 VII—26 VIII 55
2. *Metylophorus nebulosus* Steph.	11 VII—27 VII 54	12 VII—24 VIII 55
3. *Euclismia conspurcata* Ramb.	24 VI—29 VII 54	20 VII—23 VIII 55
4. *Loensia variegata* Latr.	21 VII	7 VII 55
5. *Trichadenotecnum major* Kolbe	20 VII 54	23 VII—21 VIII 55
6. *Neopsocopsis hirticornis* Reut.	—	26 VII 55
7. *N. pyrenaicus* Bad.	—	19 VII 55
8. *Amphigerontia bifasciata* Latr.	24 VI—26 VII 54	27 VI—28 VIII 55
9. *Copostigma contrarium* Reut.	19 VII—10 VIII 54	23 VII—21 VIII 55
Fam. *Mesopsocidae*		
1. *Mesopsocus unipunctatus* Müll.	18 VI—18 VII 54	20 VI—17 VIII 55
2. *Holoneura laticeps* Kolbe	18 VII— 4 VIII 54	12 VII—17 VIII 55
Fam. *Philotarsidae*		
1. *Philotarsus flaviceps* Steph.	13 IX 55	—
Fam. *Elipsocidae*		
1. *Reuterella helvimacula* Enderl.	—	8 VIII—21 VIII 55
Fam. *Peripsocidae*		
1. *Peripsocus phaeopterus* Steph.	24 VI—29 VII 54	20 VI—24 VIII 55
2. *P. subfasciatus* Steph.	20 VII— 4 VIII 54	24 VIII 55
3. *P. alboguttatus* Dalm.	18 VII— 4 VIII 54	26 VII—24 VIII 55
4. *Ectopsocus* sp.	—	4 VII—29 VII 55
Fam. *Pterodelidae*		
1. *Lachesilla pedicularia* L.	21 VI—27 VII 54	28 VI—31 VIII 55
2. *L. quercus* Kolbe	—	30 VI—23 VIII 55
Fam. *Stenopsocidae*		
1. *Stenopsocus immaculatus* Steph.	26 VI—11 VII 54	14 VII—23 VIII 55
2. *S. stigmaticus* Imh. et Labr.	—	14 VII—27 VIII 55
3. *Graphopsocus cruciatus* L.	26 VI 54	24 VIII—28 VIII 55
Fam. *Caeciliidae*		
1. *Caecilius flavidus* Steph.	24 VI—11 VIII 54	23 VI—24 VIII 55
2. *C. fuscopterus* Latr.	—	30 VI—23 VIII 55
3. *C. piceus* Kolbe	—	23 VIII 55
4. *C. gynapterus* Tet.	—	23 VIII 55
Fam. *Epipsocidae*		
1. *Bertkauia lucifuga* Ramb.	—	16 VIII 55
Fam. *Liposcelidae*		
1. *Liposcelis divinatorius* Müll.	8 VII 54	—
2. *L. silvarum* Kolbe	20 VI 54	—
Fam. *Trogiidae*		
1. *Trogium pulsatorium* L.	8 VII 54	21 VIII 55

TABLE 2

Presence of Psocoptera on Various Woody Plants

Species of Psocoptera	Species of plants																							
	Juniperus communis L.	Corylus avellana L.	Sambucus racemosa L.	Lonicera xylosteum L.	Picea abies (L.) Karst.	Pinus silvestris L.	Betula pendula Roth.	Alnus glutinosa (L.) Gaertn.	Salix pronrea L.	Sorbus aucuparia L.	Malus silvestris Mill.	Padus racemosa (Lam.) Gilib.	Quercus robur L.	Populus alba L.	P. deltoides Marsch.	P. tremula L.	Fraxinus excelsior L.	Tilia cordata L.	Frangula alnus Mill.	Acer platanoides L.	Syringa vulgaris L.
Fam. *Psocidae*																								
Psococerastis gibbosus Sulz.			+		+		+	+	+				+	+			+			+				
Metylophorus nebulosus Steph.						+	+	+	+					+			+			+				
Euclismia conspurcata Ramb.				+	+	+	+	+	+	+			+	+		+	+		+	+				
Loensia variegata Latr.							+									+								
Trichadenotecnum major Kolbe					+		+																	
Neopsocopsis hirticornis Ramb.						+																		
N. pyrenaicus Bad.													+											
Amphigerontia bifasciata Latr.					+	+	+	+	+	+			+		+	+	+			+				
Copostigma contrarium Reut.					+	+	+	+	+								+							
Fam. *Mesopsocidae*																								
Mesopsocus unipunctatus Müll.	+	+	+	+	+	+	+	+	+	+			+		+	+	+	+	+	+	+	+		
Holoneura laticeps Kolbe						+	+	+	+				+				+			+				
Fam. *Philotarsidae*																								
Philotarsus flaviceps Steph.					+	+																		
Fam. *Elipsocidae*																								
Reuterella helvimacula Enderl.							+						+											
Fam. *Peripsocidae*																								
Peripsocus phaeopterus Steph.						+	+	+	+				+		+		+			+				
P. subfasciatus Steph.				+	+								+				+							
P. alboguttatus Dalm.					+	+							+				+			+				
Ectopsocus sp.							+						+				+					+		
Fam. *Pterodelidae*																								
Lachesilla pedicularia L.		+					+			+	+		+				+					+		
L. quercus Kolbe							+						+				+					+		
Fam. *Stenopsocidae*																								
Stenopsocus immaculatus Steph.					+						+								+			+		
S. stigmaticus Imh. et Labr.																			+					
Graphipsocus cruciatus L.											+													
Fam. *Caeciliidae*																								
Caecilius flavidus Steph.			+			+		+	+	+		+	+	+			+		+	+	+			
C. fuscopterus Latr.														+			+		+	+				
C. piceus Kolbe					+														+					
C. gynapterus Tet.																								

the microflora which grows on trunks, branches, and leaves of trees and bushes and on various organic remains. The following were represented in our collections:

1) Leaf-inhabiting species (foliicoli), feeding on parasitic fungi, sometimes on the leaf tissues, the majority with high humidity requirements (Stenopsocidae, Caeciliidae); to these also belong Lachesilla quercus and Ectopsocus sp., frequently encountered on dry leaves covered with cleistocarpous powdery mildew

2) Trunk-inhabiting species (corticoli), feeding on green Protococcales algae, lichens, sometimes on the bark, the majority with low humidity requirements [Psocidae, several Peripsocidae (Peripsocus), Mesopsocidae, Philotarsidae].

3) Species-inhabiting litter and under stones (lapidicoli) similar in feeding habits to the corticoli (Bertkauia lucifuga).

The observations show that there are now sharp dividing lines between these ecological groups (Badonnel, 1951). Thus, the foliicoli may feed on Protococcales like the corticoli, although the reverse transferral is not observed.

In the Oksk Preserve it was possible to observe a preference by several species for definite stations. In linden forests with an undergrowth of young oak and hazelnut Caecilius flavidus, C. fuscopterus, and Stenopsocus immaculatus were encountered most frequently, while in oak forest with dense oak undergrowth and sparse second growth of briar and mountain ash it was Graphopsocus cruciatus and Psococerastes gibbosus; in pine forests with moderately dense clumped undergrowth of oak and pine and second growth of juniper it was Caecilius piceus, Mesopsocus unipunctatus, Euclismia conspurcata, and Perisocus phaeopterus; in willow thickets (Salix caprea L., Salix sp.) along the shore of the Pra River, it was Amphigerontia bifasciata, Copostigma contrarium, and Holoneura laticeps. It is possible that each preference is related to the growth in these stations of certain species of green algae of the order Protococcales and of parasitic fungi upon which the indicated species of Psocoptera feed (unfortunately, the species of Protococcales serving as food for the Psocoptera have not yet been determined.

Psocoptera never remain in full sunlight. According to our observations, Amphigerontia bifasciata, Copostigma contrarium, Ectopsocus sp., Lachesilla quercus, Mesopsocus unipunctatus, Stenopsocus immaculatus, S. stigmaticus, Graphopsocus cruciatus, often remain still in diffused light. Several species avoid even this illumination: they hide beneath lichens (Reuterella helvimaculata), in the cracks of bark (Liposcelis silvarum), in forest litter (Bertkauia lucifuga). The speckled brown coloration of the body and wings and the small size of the majority of the species of Psocoptera renders them inconspicuous on a background of lichens and algal growths. The larvae of Neopscopsis, covered with glandular setae to which pieces of bark and even excrement adhere, are completely invisible in the resting state and may only be discovered when alarmed. This coloration of the body and wings and the characteristic "uncleanliness" of the larvae evidently are protective adaptations.

During the second half of summer, eggs of Psocoptera may be found on the leaves and branches of trees and bushes. The trunk-inhabiting species lay eggs singly (Holoneura laticeps) or in small groups containing 7–8 eggs (Metylophorus nebulosus, Copostigma contrarium, Euclismia conspurcata, Mesopsocus unipunctatus). The exceptions are Peripsocus phaeopterus in the egg mass of which 15-20 eggs are included, and, according to Badonnel (1943), Psococerastis gibbosus, which sometimes lays as many as 80 eggs at a time. The trunk-inhabiting species usually lay their eggs on the lower surfaces of branches, arranging them in small groups (Amphigerontia bifasciata, Euclismia conspurcata, Copstigma contrarium) or in small rows with 2–3 in a row (Mesopsocus unipunctatus, Metylophorus nebulosus). In these species the masses or individual eggs are covered with a foam which quickly hardens into a substance colored like the substrate. Badonnel (1951) suggests that this substance is an anal excretion of undigested food material. The eggs of the leaf-inhabiting species look like clumps or chains located on the upper side of the leaves. The number of eggs in a mass varies, according to our data, from a mean of 10 (Stenopsocus immaculatus, Caecilius flavidus, Ectopsocus sp.) to 17 (Caecilius fuscopterus). The masses are covered with a more or less dense webbing or are devoid of such a covering (Ectopsocus sp., Lachesilla quercus). There are species which lay their eggs singly (Lachesilla quercus).

The larvae of several species, upon emergence from the egg, do not scatter along the branch but remain in a clump, forming a colony which in Psococerastis gibbosus is preserved to the moment of molting into the adult insect. In the colonies of P. gibbosus 20–25 individuals may be counted, while in Euclismia conspurcata, Stenopsocus immaculatus, Caecilius flavidus, and C. fuscopterus the colonies are formed of fewer individuals and are disbanded after reaching the third or fourth larval instars.

Several larval instars are undergone during the postembryonic development of Psocoptera. Through laboratory observations we established 6 larval instars for Psococerastis gibbosus, Metylophorus nebulosus, Caecilius flavidus, C. fuscopterus, Lachesilla quercus, L. pedicularia, and Ectopsocus sp. With regard to Lachesilla pedicularia there are concordant literature data (Badonnel, 1951).

In Psocoptera the first larval instar is preceded by the embryonic molt, which has been observed repeatedly.

The larval development of Psococerastis gibbosus was followed in the greatest detail. In this species the first-instar larva has a globular head, 8-segmented antennae, compound eyes with few facets, equally developed thoracic segments, 2-segmented tarsi, and an ovoid abdomen; it is devoid of ocelli and wing rudiments. Subsequently, from molt to molt the number of eye facets increases, through secondary division the number of antennal segments also increases to 13, and the ocelli appear. Wing rudiments appear from the second larval instar in the form of small projections from the sides of the more developed second and third thoracic segments. In the third instar these rudiments elongate and project over the sides of the thorax, not lying over each other; in the fourth instar they are applied to the sides of the thorax and are leaf-like, the anterior covering the posterior; in the fifth instar they reach the first or second abdominal segments, while in the sixth they reach the third or fourth abdominal segment and sometimes veins are distinguishable on the rudiments. In the last instar genital rudiments appear in the larvae, and toward this time the imaginal coloration is acquired. Molts occur at intervals 2 – 3 days; the duration of molting is about 30 minutes. During the last molt wrinkled milky white wings emerge from the rudiments, their distal portions turned outwards, their venation poorly defined. Gradually the wings straighten out, become raised and folded together, as in mayflies. They remain in this position until sclerotization of the veins and membrane occurs, after which the wings are lowered and folded over the back in a roof-like manner. The insect is able to fly only 2-3 hours after the last molt.

Psococerastis gibbosus and Metylophorus nebulosus begin pairing 5–6 days after molting to the adult insect. Copulation is preceded by a short nuptial dance carried out by the male. I have observed this phenomenon in Psococerastis gibbosus: the male runs excitedly around the female, quivers his wings and inflates the abdomen then slips under the female, seizes her genitalia with his, and scrambles out from under, turning so that his head faces opposite from that of the female. Copulation lasts an average of 2.5 minutes. Fertilization is by spermatophore. This means of fertilization is known (Badonnel, 1951) for Amphigerontia bifasciata, Trichadenotecnum Enderl. Reuterella Enderl., Ectopsocus McLach., Trichopsocus dalli McLach., and Lachesilla pedicularia. In the latter species the male is situated on top of the female during copulation. The female P. gibbosus lays eggs 2-3 days after pairing.

The number of generations per year depends on the diapause which intervenes during the egg or larval phase (Badonnel, 1951). In the majority of species of Psocoptera the eggs overwinter, diapause usually being observed in this phase. According to our observations, in the Moscow and Ryazan regions Psococerastis gibbosus, Metylophorus nebulosus, Copstigma contrarium and Mesopsocus unipunctatus are univoltine; Euclismia conspurcata, Amphigerontia bifasciata, and Caecilius fuscopterus are bivoltine, while Caecilius flavidus is trivoltine.

The phenomenon of parthenogenesis is rather widely distributed among the Psocoptera. Schneider (1954), after studying the type of reproduction in 40 species of Psocoptera, divides them on this basis into 6 groups:

1) unfertilized females unable to lay eggs; of the species we found, Psococerastis gibbosus, Euclismia conspurcata, Mesopsocus unipunctatus, and Graphopsocus cruciatus belong to this group;

2) unfertilized females able to lay eggs which do not develop further; in our collections, these are Metylophorus nebulosus, Stenopsocus immaculatus, and S. stigmaticus;

3) unfertilized females lay eggs which die at the beginning of embryogenesis; among our species these are Lachesilla quercus, Loensia variegata, and Trichadenotectum major;

4) unfertilized females are able to lay normal eggs but the larvae emerging from these eggs perish; of the species we found, Caecilius piceus belongs here;

5) species with sexual and parthenogentic races; in our collections these are Reuterella helvimacula and Philotarsus flaviceps;

6) reproducing only parthenogenetically; among those we found, only Caecilius flavidus belongs here.

Schneider's data on the types of reproduction in Psococerastis gibbosus, Metylophorus nebulosus, Euclismia conspurcata, Mesopsocus unipunctatus, and Caecilius flavidus were supported by our experimental observations on these species.

In conclusion some new data may be added to the little that is known concerning the parasites and predators of Psocoptera. In Liposcelis divinatorius Noland (1924) found gregarines and nematodes, the species of which were not determined. Badonnel (1951) found a specimen of Stenopsocus stigmaticus in the spring full of hyphae of an unknown fungus. I observed a similar fungal disease in August, 1955, in Caecilius flavidus. The larvae and adults of this species, infected with Entomophtora sp. (according to the kind determination of A. V. Batko), were hard to the touch and appeared to be stuck to the leaves. On the larvae and adults of Psococerastis gibbosus, Metylophorus nebulosus, Mesopsocus unipunctatus, and Holoneura laticeps sucking red mites (Trombidiidae) were occasionally found; these were not further determined. On dissection of several adult female Caecilius flavidus and C. gynapterus, and also larvae of Peripsocus phaeopterus and Mesopsocus unipunctatus, these were shown to be parasitized by larvae of Hymenoptera, the species of which have not yet been established. The oribatid mites Scapheremaeus (Cymbocremidae) and Trhypochthonius (Lohmaniidae), kindly determined by E. M. Bulanova-Zakhvatkina were repeatedly encountered in the egg masses of Metylophorus nebulosus. These mites evidently eat the eggs of this species of barklouse. According to Badonnel (1951), the eggs of Stenopsocus stigmaticus are sucked out by the bug Campyloneura virgula (Capsidae), while the egg masses of Caecilius flavidus are attacked by the mymarid Alaptus. Our observations show that the eggs of C. flavidus are also attacked by 2 other species of egg parasites of the genera Parvulinus and Anaphes of the same family.

The work was carried out in the Department of Entomology of MGU (under Prof. E. S. Smirnov). The data were prepared for publication in the Zoological Institute, AN SSSR. The author extends her sincere thanks to Aleksandr Borisovich Lang and Dmitri Ivanovich Blagoveshchenskii who rendered assistance with valuable advice during the processing of the data and the preparation of the manuscript for publication.

SUMMARY

Among 30 species of Psocoptera (see Table 1) occurring in the Moscow and Ryazan regions, Neopsocopsis hirticomis Reut., N. pyrenaicus Bad., Reuterella helvimacula Enderl., Bertkavia lucifuga Ramb. are for the first time recorded as occurring in the USSR, while Ectopsocus sp. is apparently a new species.

The earliest appearing species are Euclismia conspurcata Ramb., Amphigerontia bifasciata Latr., Stenopsocus immaculatus Steph., Caecilius flavidus Steph., Lachesilla pedicularia L., Peripsocus phaeopterus Steph. and Mesopsocus unipunctatus Mull., appearing during the second or third ten days of June, whereas the earliest species in the Ryazan region are Peripsocus phaeopterus Steph. and Mesopsocus unipunctatus Müll. found during the second ten days of June.

It has been observed that some species prefer certain definite stations.

It has been established that Psococerastis gibbosus Sulz., Metylophorus nebulosus Steph., Caecilius flavidus Steph., C. fuscopterus Latr., Lachesilla quercus Kolbe, L. pedicularia L. and Ectopsocus sp. have six larval instar.

In the Moscow and Ryazan regions Psococerastis gibbosus Sulz., Metylophorus nebulosus Steph., Copostigma contrarium Reut. and Mesopsocus unipunctatus Müll. are univoltine, Euclismia conspurcata Ramb., Amphigerontia bifasciata Latr. and Caecilius fuscopterus Latr. are bivoltine, while Caecilius flavidus Steph. has three generations per year.

The larvae and adults of C. flavidus Steph. are susceptible to infestation by a parasitic fungus Entomophtora sp. Larvae of some parasitic Hymenoptera were found in dissected adults of C. flavidus Steph. and C. gynapterus Tet., as well as in dissected larvae of Peripsocus phaeopterus Steph. and Mesopsocus unipunctatus Müll. Oribatid mites belonging to the genera Scapheremaeus (Cymbocremidae) and Trhypochthonius (Lohmanidae) were found in egg masses of Metylophorus nebulosus Steph. The eggs of Caecilius flavidus are attacked by egg parasites of the genera Anaphes and Parvulinus (Mymaridae).

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THE SCALE INSECT FAUNA (HOMOPTERA, COCCOIDEA) OF THE LENINGRAD REGION

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The coccid fauna of the Leningrad region has scarcely been touched. Neither the distribution, local spread, nor biology of the overwhelming majority of the species is known; the specific composition of the fauna is far from clarified. In Kirichenko's accounts (1930, 1940) of the USSR fauna there are some very meager data on the coccid species of the Leningrad region. At the present time 24 species are recorded in surveys of the USSR fauna (Borkhsenius, 1949, 1950, 1957) for the region which concerns us.

We investigated the Leningrad fauna in 1956-1957 and in part of 1955. The collected material comprises 52 species, of which 30 are recorded from the Leningrad region for the first time, 15 are new to the northwest USSR, and 7 are recorded for the first time in the USSR fauna. Of those species previously recorded for the Leningrad region, Phenacoccus mespili (Geoffr.) and Acanthococcus uvae-ursi (L.) were not found. Thus, the coccid species composing the Leningrad fauna are now numbered at 54.

The present work is the first survey of the coccid fauna of the Leningrad region and contains data on the distribution, ecological spread, biology, and injuriousness of the species. An attempt is made to characterize the fauna investigated according to its biological, ecological, and zoogeographical relationships and to estimate its injuriousness.

The author's collections served as a basis for the study; in addition, material preserved in the collection of the Zoological Institute, AN SSSR, was used (in which case the surname of the collector is stated). The arrangement of localities is according to a system of geobotanical subdivisions proposed by Tsinzerling (1932; Leningrad region without the Karelian section) and also Abramova and Kozlova (1957; Karelian section). The regions investigated were: the Vyborgskii (Vyb.), Priozersko-Lesogorskii (Proz.), Roshchinskii (Roshch.), Primor'e (Prim.), Vostochno-izvestnyakovyi (V-izv.), Siluriiskii (Sil.), Luzhskii (Luzh.), and Svirskii (Svir.); separate collections were made in the Sosnovsko-Priozerskii (Sos.), Toksovskii (Tok.), and Priladozhskii (Lad.) regions. Thus the northern, southern, eastern, western, and central portions of the region were included. In the event that a species was found in all the points investigated its collection localities were omitted.

The present work was carried out in association with E. S. Sugonyaev, who studied the parasitofauna of the coccids of the Leningrad region. Data on the species of parasitic chalcids and also on their abundance were taken from his work (Sugonyaev, 1958); in which case the reference (Sugonyaev) is given; this reference is absent if results of counts or observations by the present author are used. The predatory mite Hemisarcoptes malus Schim. was determined by V. B. Dubinin, the predatory bug Calacoris biclavatus H.-S. was determined by A. N. Kirichenko, and the predatory fly Leucopis (Leucopomyia) silesica Egg. was determined by V. N. Tanasiichuk. The author takes this opportunity to thank all of them.

For presenting biological data the larvae are conventionally indicated by the letter L (L_1 – 1st instar larva, L_2 – 2nd instar larva, and so forth).

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Fam. ORTHEZIIDAE

Orthezia urticae (L.)—Nettle scale. Ubiquitous, in all forest associations except dry pine groves. On the leaves and stems of various grassy plants: nettle (Urtica dioica L.), stone bramble (Rubus saxatilis L.), wild strawberry (Fragaria vesca L.), clover (Trifolium repens L.) and others. Common, but not forming large colonies.

O. cataphracta (Shaw). V-izv.: Sablino, Sept. 13, 1956 (3♀♀), right bank of the Tosno. In cracks in the bark of Solidago virga aurea L. and Hieracium umbellatum L.—First record from the Leningrad region.

Newsteadia floccosa (de Geer). Ubiquitous, in green moss and sphagnum associations. On moss, rotten leaves, heather stems (Calluna vulgaris Salisb) sunk into moss, bilberry (Vaccinium myrtillus L.), red bilberry (V. vitis idaea L.), wild strawberry (Fragaria vesca L.). According to Schmutterer (1952), it may feed on fungus hyphae and rotting leaves. Very common, found in small colonies. ♀♀ and LL are found in the colonies during the entire vegetative period.

Fam. MARGARODIDAE

Matsucoccus insignis (Borchs.). Roshch.: Molodezhnyi (north of Zelenogorsk), green moss pine grove; Prim.: Leningrad, Forestry Academy park (M. N. Rimskii-Korsakov, N. S. Borkhsenius); V.-izv.: Pavlovsk, park (M. N. Rimskii-Korsakov). In cracks and under the bark of pine (Pinus silvestris L.). Rare. ♂♂ fly at the end of May to the beginning of June, the ♀♀ beginning to construct ovisacs at the same time. Hatching during the second half of June. Crawlers are lemon yellow. The young ♀♀ are very mobile; on sunny days they wander in a lively manner over the surface of the bark. The ovisacs and the ♂ cocoon consist of silky white, loosely woven, curling threads.

Fam. PSEUDOCOCCIDAE

Pseudococcus novae Nass. Prioz.: Gory (shore and islands of Lake Vuoksa west of Priozersko), July 28, 1956 (end of oviposition), July 18, 1957 (L_3); Vyb.: Vyborg (N. V. Nasonov), shrub and pine and white moss and pine associations. On the young branches of juniper (Juniperus communis L.). Extremely rare.

P. walkeri (Newst.). Prioz.: Gory, July 30, 1956 (♀♀), mixed shrubby forest; V.-izv.: Pushkin, Aleksandrovskii Park, Aug. 22, 1955 (♀♀). On the leaves of Calamagrostis epigeios Roth. Extremely rare. Young ♀♀ very mobile, covered with powdery wax. A row of short waxy plates runs along the edges of the body and 4 stout waxy threads issue from the end of the body: 2 median long ones and 2 lateral short ones. Known from Western Europe, recorded from the USSR for the first time.

P. perrisii (Sign.). Roshch.: Zelenogorsk, Sept. 20, 1956 (ovipositing ♀♀), southern sandy slope of Pukhtol Mt.; Luzh.: Luga (N. V. Nasonov). At the base of stems of Calamagrostis epigeios Roth. Extremely rare.

P. graminellus Borchs. Luzh.: Luga, July 30, 1956 (♀♀), garden; Aug. 3, 1908 (N. V. Nasonov). At the base of the stems and behind the axils of leaves of Agropyron repens (L.) and other grasses. Rare.

P. placatus Borchs. Prioz.: Gory, July 31, 1956 (♀♀), Aug. 6, 1956 (♀♀); Vyb.: Sokolinskoe, Aug. 2, 1957 (♀♀); Luzh.: Luga, July 5, 1956 (♀♀). Mixed flood-plain shrubby forests, green moss and pine groves. On the leaves of Calamagrostis lanceolata Roth., Agrostis alba L., Poa nemoralis L. Rare, but sometimes found in large colonies. Young females very similar in outward appearance to P. walkeri (Newst.). Recorded from the northwestern USSR for the first time.

Ripersia scirpi Green. Our material agrees fully with Green's description (1921) but because of the brevity of the latter the determination cannot be considered final until type material has been compared. Luzh.: Luga, Aug. 18, 1956 (20 ♀♀), troph. At the bases of leaves of Carex sp. The females are pink. Known from England; recorded from the USSR for the first time.

Phenacoccopsis nasonovi Borchs. Luzh.: Luga, July 24, 1956 (3 ♀♀), Aug. 17, 1956 (2 ♀♀ with ovisacs) in open, slightly grassy, sandy borders of heathland-pine association; Aug. 2, 1908 (N. V. Nasonov). On the bark of Carex sp. and undetermined cereals.

Spinococcus calluneti (Lndgr.). Ubiquitous both in dry pine groves and heathlands and in green moss and sphagnum-pine forests, more rarely in shrub and pine forests. On the stems of heather (Calluna vulgaris Salib.),

hog-cranberry (Arctostaphylos uva ursi Spr.), bilberry (Vaccinium myrtillius L.), red bilberry (V. vitis idaea L.), bog bilberry (V. uliginosum L.), Empetrum nigrum L., and cranberry (Oxycoccos quadripetalus Gilib.). Very common, often abundant. Overwinters in the egg stage. Crawlers hatch at the beginning of June. ♂♂ and ♀♀ appear in July; oviposition is in August to September. ♀♀ and LL are pink, covered with powdery wax with loose, short, waxy scales at the end of the body. The eggs are yellow, the ovisacs white, loose. This is the first record from the Leningrad region.

Phenacoccus aceris (Geoffr.) Ubiquitous, in all types of forests except dry pine groves, also in parks, ornamental stands, gardens, and berry cultivations. On the branches and trunks of hawthorn (Crataegus oxyacantha L.), honeysuckle (Lonicera tatarica L.), maple (Acer platonoides L.), linden (Tilia cordata Mill.), apple (Malus domestica Borkh.), birch (Betula verrucosa Ehrh., B. pubescens Ehrh.), mountain ash (Sorbus aucuparia L.), alder [Alnus glutinosa (L.) Gaerth., A. incana Willd.] and acacia (Caragana arborescens Lam.). Very common but found singly, rarely reaching high numbers only on ornamental plantings. Damages hawthorn and honeysuckle locally in ornamental plantings. Larvae of ♂♂ and ♀♀ overwinter in tomentose cocoons in the cracks in the bark of trunks and branches. At the onset of warm days (at the end of April) the ♀ larvae emerge onto the surface of the bark in search of a feeding place. At the second half of May the ♂♂ and ♀♀ appear. From the end of May to the beginning of June oviposition begins and the crawlers hatch at the end of June. During the summer the larvae develop on the leaves and young branches and at the end of August they migrate to the branches and trunk for overwintering. It is probable that the reason for the low numbers of this mealy bug is the effective activity of the parasite Anagyrus schoenherri (Westw.) and in part Aphycus apicalis (Dalm.).

Ph. mespili (Geoffr.). V.-Izv.: Pushkin, Aleksandrovskii Park (N. S. Borkhsenius, oral communication; the author was not able to see the material). On apple (Malus domestica Borkh.).

Paroudablis piceae (Loew). Ubiquitous, in all types of forest which include spruce (Picea excelsa Link.). On the needles of spruce. Very common, but large colonies are rarely found. The ♀♀ appear at the end of June; oviposition is in July. The ♀♀ are pink and covered with powdery wax; the color of the eggs is from yellow to beige.

Peliococcus balteatus (Green). Ubiquitous, in all types of forest except dry pine groves. On the leaves of Agropyron repens (L.) P. B., Dactylis glomerata L., Calamagrostis spp., Festuca spp., Poa spp., and other cereals. Very common, but found singly or in small colonies. The ♀♀ aggregate at the end of July; they are yellowish green, covered with powdery wax with short, loose scales along the sides of the body. Known from the south shore of the Crimea and from England; recorded for the first time from the northwestern USSR.

Peliococcopsis parvicerarius (Goux). Described by Goux (1937) under the generic name of Phenacoccus, but by modern terminology it should belong to the genus Peliococcopsis Borkhs. Svir.: Podporozh'e, Aug. 8, 1957 (10 ♀♀), railway embankment. At the base of the stems of Poa pratensis L. ♀♀ are light beige. Known from France; recorded from the USSR for the first time.

Ceroputo pilosellae Sulc. Roshch.: Sestroretsk, Sept. 23, 1956 (L_3); Sil.: Kingisepp, July 3, 1957 (♀♀); Luzh.: Luga, June 13, 1957 (♀♀). Heathlands and heath and pine groves, sometimes going on to very sparse sphagnum and pine groves. On the lower side of the leaves of hog-cranberry (Arctostaphylos uva ursi Spr.), Hieracium pilosella L., Antennaria dioica Gaerth., heather (Calluna vulgaris Salisb.), cranberry (Oxycoccos quadripetalus Gilib.), and Veronica officinalis L. Rare. Ovoviviparous species; hatching of crawlers was observed on July 3, 1957. The ♀♀ are greyish green, covered with loose, white, waxy scales. Recorded from the Leningrad region for the first time.

Coccura comari (Kunow). Prioz.: Priozersk, Jul. 26, 1956 (10 ♀♀ and L_1L_1), railway embankment; Roshch.: Sestroretsk, Sept. 23, 1956 (1 ♀ and L_1L_1), heathland and pine association on the slope of a sandy hill; Luzh.: Luga, July 6, 1956 (3 ♀♀), shore of Lake Omchino, sparse pine woods; Tolmachevo, Aug. 11, 1956, shore of the Luga R., oak forest. At the base of raspberry stems (Rubus idaeus L.) and those of stone bramble (R. saxatilis L.). Extremely rare. An ovoviviparous species; hatching of crawlers was observed on July 16, 1956; the crawlers are lemon yellow. Recorded from the Leningrad region for the first time.

Fam. ERIOCOCCIDAE

Acanthococcus uvae-ursi (L.). Luzh.: Luga, July 5, 1934 (Nemeritskii). On hog-cranberry (Arctostaphylos uva ursi Spr.).

Rhizococcus insignis (Newst.). Vyb.: Vyborg, July 31, 1957 (♀♀); V.-Izv.: Pushkin, Aleksandrovskii Park, Aug. 22, 1955 (♀♀ with ovisaca), Pavlovsk, Sept. 4, 1956 (♀♀ with ovisacs); Luzh.: Luga, July 5, 1956 (♀♀), Aug. 26, 1956 (♀♀ with ovisacs). In all types of forests except dry pine groves. On the leaves of Calamagrostis arundinacea Roth., Poa sp., and other cereals. The color of the egg masses is from white to cream, the eggs are yellow. This is the first record from the northwestern USSR.

Greenisca glyceriae (Green). Prioz.: Priozersk, Muly 26, 1956 (♀♀); Lad.: Lake Ladoga, July 27, 1957 (♀♀); Vyb.: Vyborg, Aug. 5, 1957 (♀♀), Bysotsk, Aug. 3, 1957 (♀♀); Roshch.: Repino, Sept. 5, 1956 (♀♀ with ovisacs); Luzh.: Luga, July 23, 1956 (♀♀), July 24,1956 (♀♀), Aug. 26, 1956 (♀♀ with ovisacs). At sandy locations: on the shore of the sea and of Lake Ladoga, in dry pine groves, on railway embankments. At the bases of the stems of Festuca ovina L., Agropyron repens (L.) P. B., Agrostis vulgaris With., Elymus arenarius L., and Calamagrostis sp. Fairly frequent, found in small colonies. The ♀♀ are bright pink, sparsely sprinkled with powdery wax. The eggs are bright pink, the egg sacs firm, white to yellowish. Recorded from the Leningrad region for the first time.

G. placida (Green). Luzh.: Luga, Aug. 20, 1956 (30 ♀♀ with ovisacs), side of a small stream in a forest clearing. On leaves of Agropyron repens (L.) P. B. Recorded from the Leningrad region for the first time.

Fam. KERMOCOCCIDAE

Kermococcus quercus (L.). Luzh.: Tolmachevo, July 7, 1956, Luga River, oak forest; in very small numbers. In the parks of Leningrad, Pushkin, and Petrodvorets it is not rare and sometimes achieves large numbers, killing branches (in the Forest Academy Park). On the trunks and branches of oak (Quercus robur L.). The male and female L_1L_1 and L_2L_2 overwinter. The ♂♂ fly at the end of May; the crawlers hatch at the end of June. The biology of the species in the Leningrad region was dealt with in detail by Nasonov (1910). The numbers of this insect are greatly reduced (by up to 70%) as a result of the activities of the parasite Geniocerus thysanotus (Forst.) (Sugonyaev).

Fam. ASTEROLECANIIDAE

Asterolecanium quercicola (Bouché). Roshch.: Sestroretsk, Sept. 23, 1956 (L_2L_2 and ♀♀), shore of the Gulf of Finland, sparse oak forest. Fairly abundant, killing young branches. It is not numerous in Petrodvorets Park. On the twigs of oak (Quercus robur L.). The parasites Habrolepis dalmani (Westw.) and Euaphycus astorolecanii Merc. destroy over half of the population (Sugonyaev). Recorded from the first time from the northwestern USSR. USSR.

Fam. COCCIDAE

Psilococcus parvus Borkhs. Vyb.: Vyborg, Aug. 4, 1957 (5 ♀♀); Prim.: Sestroretsk, Sept. 23, 1956 (1 ♀); Svir.: Podporezh'e, Aug. 9, 1957 (15 ♀♀). In sphagnum and pine associations. At the bases of the leaves of Carex pallescens L. and C. canescens L. Extremely rare. The ♀♀ are bright pink. Recorded from the Leningrad region for the first time.

Luzulaspis luzulae (Dufour). Ubiquitous in all types of forests except dry pine groves. On the leaves of Luzula pilosa L. and Carex spp. Nor uncommon, but rarely observed in large colonies. Overwinters in the egg stage; the egg sacs are observed at the end of July to the beginning of August. Both sexes are observed. The color of the ♀ is yellow to pale pink with two brown stripes running down the back (easily seen only in young ♀♀). The eggs are yellowish pink. Recorded for the first time from the Leningrad region.

L. montana Schmutt. Luzh.: Luga, July 24, 1956 (15 ♀♀, empty ♂ cocoons), Aug. 18, 1956 (♀♀ with ovisacs). Edge of a heath and pine association with sparse grass, sand. On the leaves of Carex sp. Known from Germany; recorded from the USSR for the first time.

L. borchsenii Rehacek. Vyb.: Sokolinskoe (environs of Vyborg), Aug. 2, 1957; Roshch.: Repino, Sept. 5, 1956, Sestroretsk, Sept. 23, 1956; V.-Izv.: Pushkin, Aleksandrovskii Park, Aug. 20, 1955; Luzh.: Luga, Jul. 24, 1956, Aug. 18, 1956, Aug. 26, 1956. In marshy forests. On leaves of Carex sp. Rare, but sometimes forming considerable colonies. The eggs overwinter in the egg sacs; oviposition is in August. The coloration of the ♀ is pink. The eggs are pink.

This species was described by Rehacek (1959) from Czechlovakia. We were able to see the type material sent by Rehacek to N. S. Borkhsenius.

Parafairmairia delicata Borkhs. Luzh.: Luga, Aug. 16, 1956 (♀♀), Aug. 26, 1956 (♀♀), edges of a heathland-pine association with sparse grass, sphagnum-pine association. On the leaves of Carex spp. Only two concentrations were observed, but these included very many individuals: up to 20 on a plant. Recorded for the first time from the Leningrad region.

P. gracilis Green. Luzh.: Luga, Aug. 20, 1956 (2 ♀♀), sides of a small stream in a forest, Aug. 26, 1956 (4 ♀♀), sphagnum-pine association. On the leaves of Carex sp. and Agropyron repens (L.) P. B. Known from England and Germany; recorded from the USSR for the first time.

Eriopeltis lichtensteinii Sign. Vyb.: Vyborg, Aug. 5, 1957, railway embankment; Prioz.: Gory, Jul. 31, 1956, mixed tree-shrub association; Priozersk, Sept. 9, 1956, green moss pine association; V.-izv.: Pushkin, Aleksandrovskii Park, Aug. 31, 1956; Luzh.: Luga, July 22, 1956, sand pit. On the leaves of Calamagrostis epigeios Roth. Rare; in moist locations it forms large colonies, up to 15 individuals on a leaf, while in dry locations it occurs singly. Overwinters in the egg stage, the ♂♂ and ♀♀ appearing at the end of July; oviposition is in August. The parasite Trichomasthus cyaneus (Dalm.) destroys up to 30% of the population of this species (Sugolyaev). The eggs are eaten by the larvae of the predatory fly Leucopis (Leucopomyia) silesiaca Egg. Recorded from the Leningrad region for the first time.

E. rasinae Borkhs. Ubiquitous, in all types of forests. On the leaves of Agrostis vulgaris With. Not uncommon, but found singly or in small colonies. Develops at the same times indicated for the preceding species. Coloration of the ♀ pale pink.

E. plumeus Borkhs. Ubiquitous, in all types of forests, but prefers dry pine groves and heathlands. Encoun ered more rarely than is the preceding species. On the leaves of Festuca ovina L. Develops at the same time as E. lichtensteinii Sign. Outwardly similar to the preceding species, differing from it in its smaller size and its downier egg sac, and also in the pale yellow color of the male.

Pulvinaria betulae (L.). Ubiquitous in distribution, in all types of forests except dry pine groves, also in parks, ornamental plantings, and berry cultivations. On the branches, rarely on the trunk, of birch (Betula verrucosa Ehrh., B. pubescens Ehrh.), willow (Salix spp.), mountain ash (Sorbus aucuparia L.), currant (Ribes nigrum L., R. rubrum L.), and alder (Alnus incana Wild., A. glutinosa (L.) Gaerth.). Rare. Populations on different plants differ in sex ratio. On currant the colonies consist of few ♀♀ and numerous ♂♂. Reproduction is evidently bisexual. On the other plants separate small colonies of ♀♀ or single ♀♀ and very large (up to 100-individual) colonies of ♂♂ are found. The ♂♂ and ♀♀ develop on different plants which are situated quite far apart from one another. Reproduction is evidently parthenogenetic. The ♀♀ and L_2L_2 overwinter. Locally there is a high infestation by the parasite Encyrtus swederi Dalm.

Phyllostroma myrtilli (Kalt.). Luzh.: Tolmachevo, July 7, 1956 (2♀♀), hill overlooking the Luga River, green moss-pine association. On heather (Calluna vulgaris Salisb.) and bilberry (Vaccinium myrtillus L.). Recorded from the Leningrad region for the first time.

Parthenolecanium corni (Bouché). Roshch.: Repino, Sestroretsk; Tok.: Kavgalovo; Sil.: Mozhaiskoe, Veimarn; V.-izv.: Sablino; Luzh.: Luga. Along the shores of rivers and seas in open places with sandy soil. At the bases of the stems of raspberry (Rubus idaeus L.), more rarely on the branches of bird cherry (Padus racemosa Schneid.) and hazelnut (Corylus avellana L.). Rare. A large concentration on hazel should be particularly pointed out; this was in a shrub-spruce association on Voron'ya Mt. in Moshaiskii and bore relict characteristics. In the parks and ornamental plantings of Leningrad and suburbs (Pushkin, Luga, Priozersk, Kingisepp) it is very common and sometimes achieves great numbers. On the branches of acasia (Caragana arborescens Lam.), sometimes of spiraea (Spiraea media Schmidt), hawthorn (Crataefus oxyacantha L.), ash (Fraxinus excelsior L.), and bird cherry. Damages acacia locally. In berry cultivarions it is found everywhere on gooseberry (Grossularia reclinata Mill.), currant (Ribes nigrum L., R. rubrum L.), and rarely on raspberry; it is sometimes injurious. Very rare in apple orchards (Malus domestica Borkh.).

The L_2L_2 overwinter on branches. At the end of April they begin to move around in search of places suitable for feeding. The ♀♀ appear at the beginning of June and quickly begin to lay eggs. The crawlers emerge at the second half of July. The LL develop on leaves and young branches and migrate to the branches in autumn.

Males were not found; reproduction is parthenogenetic. Parasites [Cheiloneurus graeffei Rusch., Metaphycus insidiosus Merc., Coccophagus lycimnia (Wlk.)] do not play a decisive role in the population dynamics of this species, infestation rarely exceeding 10%. The predatory beetle Brachytarsus nebulosus Först. destroys about half the eggs of the scale and sometimes about 20% of the eggs are destroyed by predatory larvae of undetermined species of flies. Up to 5% of the eggs are attacked by the predatory bug Calacoris biclavatus H.-S. It pierces the dorsum of the ♀ and sucks the eggs dry such that these become a sticky mass. In subsequent years a sharp drop in the numbers of the pest occurred as a result of unfavorable climatic conditions. The severe winter of 1955/1956 caused a mortality of 64% among the overwintering L_2L_2. A considerably greater reduction in the numbers of this insect occurred in 1957, when on the same acacia bushes which in 1956 had been covered with large colonies of the scale it became difficult to find single individuals of the live insect. It appears to us that the reason for this phenomenon was an early autumn frost in 1956 (at the beginning of September) which caused a premature leaf fall. The larvae did not succeed in migrating to the branches for overwintering and fell to the ground with the leaves; according to Suter's observations (1950) larvae do not migrate to the branches from fallen leaves and perish.

P. fletcheri (Ckll.). Prim.: Leningrad, July 17, 1956 (♀♀ with eggs), Primorskii Park. On the leaves and branches of Thuja sp. One small concentration. Not found in natural biocoenoses; evidently introduced with planted material. The young ♀ is ruddy with a light brown reticular design. Recorded for the first time from the Leningrad region.

Eulecanium transvittatum (Green). Prioz.: Gory, June 18, 1957 (1 ♀), mixed tree-shrub association. On the branches of birch (Betula verrucosa Ehrh.). The young ♀ is dark tan with transverse stripes of an ivory color, densely covered with powdery wax. Known from England; recorded from the USSR for the first time.

E. ciliatum (Dougl.). Prioz.: Gory, June 18, 1957 (1 ♀), mixed tree-shrub association. On the branches of alder (Alnus incana Willd.). The female is light brown, uniform in color. In the USSR this species is known from the Caucasus and the Primor'e region; it is recorded from the northwest area for the first time.

E. franconicum (Lndgr.). Observed in all the areas investigated but encountered extremely seldom, singly or in small colonies. On the twigs of bilberry (Vaccinium myrtillus L.), bog bilberry (V. uliginosum L.), red bilberry (V. vitis idaea L.), and heather (Calluna vulgaris Salisb.). The ♀♀ appear at the end of May to the beginning of June; oviposition is in June. The insects from heather differ significantly from those from the other food plants in the shape of the body, the dimensions, and the color of the live and dead females, and also in the coloration of the eggs and larvae, although microscopical differences are not observed. We will not consider this matter in detail here since a special communication will be devoted to it. With regard to collecting locality the heather form is associated with well isolated heathlands, heathland-pine associations, and sparse sphagnum-pine areas; the second form is found in denser pine forests and in green moss-spruce associations. Both forms are subject to heavy parasitization: the heather form by Encyrtus infidus (Rossi) and Discodes minor (Merc.), the bilberry form by Blastothrix truncatipennis (Ferr.).

E. douglasi (Sulc). Vyb.: Vyborg (N. V. Nasonov); Luzh.: Luga, June 13, 1957 (7 ♀♀), near Lake Omchino, sparse green moss and pine association. On the slender twigs of birch (Betula verrucosa Ehrh.). Strongly parasitized by Encyrtus infidus (Rossi). The young ♀ is light tan (becoming darker), with one longitudinal and several transverse dark tan stripes. Along the sides of the body there are white, waxy ciliae.

E. caraganae Borkhs. Ornamental plantings in Leningrad and Pushkin. On the branches of acacia (Caragana arborescens Lam.). Rare, but sometimes achieving great numbers and killing the branches. Not found in natural biocoenoses; introduced. The L_2L_2 overwinter on the branches, often beneath old females closely applied to the substrate, which makes them poorly susceptible to contact by chemicals. The ♀♀ appear at the end of May, oviposition is in June, and hatching is in July. The LL develop on leaves and young twigs. The larvae of Brachytarsus nebulosus Först. destroy up to 30% of the eggs and the predatory bug Calacoris biclavatus H.-S. destroys up to 6%.

E. mali (Schr.). Staryi Peterhof, Gory, in gardens. On the branches of apple (Malus domestica Borkh.). Very rare. Not found in natural biocoenoses, introduced. The observation years coincided with a depression of the species caused, on the one hand, by the activity of parasites (of 34 adult females 7 were infested by parasites) and on the other by unfavorable climatic conditions (winter cold, early autumn frosts). During the course of two years we were unable to find one single live insect in spite of the presence of old females and ♂ cocoons. Recorded from the northwestern USSR for the first time.

E. tiliae (L.). Prioz.: Gory, mixed tree-shrub floodlands. Luzh.: Luga, bank of the Luga River, deciduous forst. On the branches of linden (Tilia cordata Mill.), maple (Acer platanoides L.), alder (Alnus incana Willd., A. glutinosa (L.) Gaerth), mountain ash (Sorbus aucuparia L.), aspen (Populus tremula L.), and birch(Betula verrucosa Ehrh.). In the ornamental cultivations of Pushkin, Staryi Peterhof, and Luga. Rare. The L_2L_2 overwinter on the branches. The ♀♀ appear in May, oviposition is in June, and hatching occurs at the end of July. In 1957 and especially in 1956 a depression was observed. Many insects died in the winter of 1955/1956 and during 1956; live insects could be found only on the low bushes which during winter are covered with snow. Parasites destroy an average of up to 20% of the individuals (sometimes up to 80%). In places the eggs are destroyed in considerable numbers by the larvae of Brachytarsus nebulosus Forst. and some undetermined flies. The young ♀♀ are light brown with interrupted transverse yellow stripes. The eggs are lemon yellow, the crawlers light beige.

Physokermes piceae (Schr.). Ubiquitous, in moist forests and parks. On spruce (Picea excelsa Link.). Very common and often found in large numbers. The L_2L_2 overwinter; the ♀♀ appear at the beginning of June, oviposition is at the end of June. The ♀♀ are located under the bud scales at the base of one-year-old shoots. The ♂♂ are extremely rare (4% of the population) and are located on the needles; they are strongly parasitized. In 1956 and especially in 1957 a strong depression was observed. On the trees which previously had been strongly infested only a few live individuals were preserved. Of some significance in this respect were the frosts of the winter of 1955/1956 (mortality 66%) and the fundamental role played by the activities of the parasites Pseudorhopus testaceus (Ratz.), Microterys lunatus (Dalm.) and Aphycoides merceti Ferr., which together destroy 80-90% of the scale (Sungonyaev). A number of eggs are destroyed by Brachytarsus nebulosus Forst.

Ph. latipes Borkhs. In referring to the spruce scales (and to other species) the author used the specific names adopted in the "Fauna of the USSR" (Borkhsenius, 1957). Schmutterer (1956) uses the name Ph. piceae (Schr.) for the large spruce soft scale and Ph. hemicriphus (Dalm.) for the small one. Roshch.: Zelenogorsk; Luzh.: Luga. Green moss and spruce associations. Like the preceding species, this one lives on spruce, but differs in that the ♀♀ are located not only at the bases of the first-year shoots but also at the bases of the leaves. The larvae of the ♂♂ suck the leaves and in contrast to the preceding species they are numerous (up to 85% of the population). It prefers young trees. Extremely rare; after two years only 4 parasitized trees were observed (in 2 locations), of which 2 trees were heavily infested and strongly inhibited. It develops at the same intervals as the preceding species. The flight of the ♂♂ is observed at the beginning of June. Schmutterer's (1956) assertion that the development of the small spruce scale lags behind that of this one by 3-4 weeks was not supported by our observations. As in the preceding species, a depression was observed, caused primarily by the effective activity of the parasites Chiloneurus elegans (Dalm.), Microterys lunatus (Dalm.), and Aphycoides merceti Ferr., which destroy 80-90% of the females, and Coccophagus insidiator (Dalm.), which destroys more than half the males (Sugonyaev). A considerable portion of the eggs are eaten by the larvae of Brachytarsus nebulosus Forst. Recorded from the Leningrad region for the first time.

Fam. DIASPIDIDAE

Syngenaspis parlatoriae Sulc. Roshch.: Zelenogorsk, May 12, 1956 (10 ♀♀), edge of a green moss and spruce (Picea excelsia Link.). — In the USSR known only from Crimea; recorded from the northwestern USSR for the first time.

Anamaspis Loewi (Colvée). Prim.: Zelenogorsk, Pukhtola Mt., dry pine grove. On the needles of pine (Pinus silvestris L.). A concentration of several hundred individuals was found, causing considerable damage. The L_2L_2 overwinter. The ♂♂ and ♀♀ appear at the beginning of June. The ♀ is light violet in color, the puparia light brown. The eggs and crawlers are violet. Recorded from the Leningrad region for the first time.

Lepidosaphes ulmi (L.). Vyb. Vysotsk; Sos.: Gromovo; Roshch.: Solnechnoe, Repino, Sestroretsk; Sil.: Kingisepp; Luzh.: Luga. Occupies the most lighted and warmest locations: Heathlands and heathland-pine associations, sometimes found in very sparse sphagnum and pine associations (Kingisepp). At the south of the region (Luga) it invades the edges of the green moss and pine associations. The principal food plants are heather (Calluna vulgaris Salisb.), more rarely hog cranberry (Arctostaphylos uva ursi Spr.) and red bilberry (Vaccinium vitis idaea L.) and, in moist locations, also bilberry (V. myrtillus L.), bog bilberry (V. uliginosum L.), cranberry (Oxycoccos quadripetalus Gilib.), birch (Betula verrucosa Ehrh., B. pubescens Erh.), raspberry(Rubus idaeus L.), Ledum palustre L., and Andromeda polyfolia L. It is rare in natural biocoenoses. It is common in the ornamental platings and parks of Leningrad, Pushkin, and Luga, often achieving large numbers. It is very polyphagous and

is encountered on different trees and bushes. It injures cotoneaster (Cotoneaster integerrima Medic., C. lucida Schlecht.), hawthorn (Crataegus oxyacantha L.), linden (Tilia cordata Mill.), and others, causing the death of individual branches, rarely the whole plant. It is frequently found in gardens and sometimes injures apple (Malus domestica Borkh.). This species is recorded in berry cultivations by Samoilovich (1955). The eggs overwinter. Hatching of the crawlers is at the beginning of June and the appearance of the ♀♀ and the flight of the ♂♂ is during the second half of July. Oviposition occurs from the end of August to the end of September. Two intraspecific biological forms exist in this species: a bisexual one and a parthenogenetic one, developing on different species of plants. The first one is recorded for both primary and secondary biocoenoses, the second one only for secondary biocoenoses. The species suffered heavily from the frosts of the winter of 1955/1956. On several host species (apple, cotoneaster, hawthorn, ash and bird cherry) the entire or almost the entire overwintering population located above the snow cover died out. On these plants the numbers of scales were so reduced that it often became difficult to find single live specimens on plants which had been previously heavily infested. The cold, rainy summer and early autumn frosts of 1956 hindered the recovery of the species and caused a reduction in fecundity to $1/7$ in comparison with 1955. Fecundity varies according to the food plant (from 19.6 to 71.7 eggs in 1955; 5.7 to 35.5 in 1956, and 13.7 to 65.4 in 1957). We are considering the biology of this species in a separate work (1959). Entomophages do not appear to wield much influence on the numbers of this scale. The infestation by the parasites Anabrolepis zetterstedti (Westw.), Apterencyrtus microphagus (Mayr), and Aphytus sp. does not exceed an average of 10%. The predatory mite Hemisarcoptes malus Schim. is more effective; attaching all developmental stages of the scale, it destroys 20-30% of the population.

Chionaspis salicis (L.). Widely distributed in all regions, in all moist tree-shrub associations, forest parks, ornamental stands, and berry cultivations. It is the most abundant and commonest species both in forests and in secondary biocoenoses; it often infests plants heavily and causes damage. It causes a reduction in growth, killing of individual branches and whole plants; furthermore, in berry cultures it causes a reduction in yield. The plants preferred are bilberry (Vaccinium myrtilus L.), bog bilberry (V. uliginosum L.), red bilberry (V. vitis idaea L.), willow (Salix spp.), mountain ash (Sorbus aucuparia L.), linden (Tilia cordata Mill.), aspen (Populus tremula L.), ash (Fraxinus excelsior L.), currant (Ribes nigrum L., R. rubrum L.); it also attacks cranberry (Oxycoccos quadripetalus Gilib.), poplar (Populus spp.), lilac (Syringa spp.), alder (Alnus glutinosa (L.) Gaerth., A. incana Willd.), gooseberry (Grossularia reclinata Mill.), maple (Acer platanoides L.), Ledum palustre L., Andromeda polyfolia L., birch (Betula verrucosa Ehrh.), and cotoneaster (Cotoneaster lucida Schlecht.). Overwinters in the egg stage. Hatching of the crawlers occurs at the beginning of May. The ♂♂ and ♀♀ appear at the end of July. In 3-4 weeks it outstrips the previous species in development. It is well adapted to local climatic conditions; mortality after the winter of 1955-1956 was not over 7%. Fecundity varied from 24.8 to 60.1 eggs in 1955 and from 19.3 to 53.8 in 1956. The parasites Pteroptrix dimidiata Westw., Apterencyrtus microphagus (Mayr), and Thomsonisca typica (Merc.) are not very effective, infestation not exceeding several percent. The most effective activity is that of the predatory mite Hemisarcoptes malus Schim.; attacking all stages of the scale, it destroys 35% of the population. Locally Chilocorus bipustulatus L. and Ch. renipustulatus Scr. destroy the scale colonies almost entirely, but on the whole their effectiveness is not over 30%.

Aulacaspis rosae (Bouché). In the ornamental plantings of the Leningrad, Pushkin, and Priozersk parks. Not encountered in natural biocoenoses, introduced. On the branches of wild rose (Rosa canina L.). Rare, but sometimes abundant and injurious. The yearly cycle has not been completely followed; the absence of diapause is characteristic of the species: overwintering occurs in all developmental stages, testifying to the fact that the yearly cycle is not adapted to the local conditions. Mortality during the winter months is high and even beneath the snow cover reached 70% during the winters of 1955/1956 and 1956/1957. The parasites Adelencyrtus aulacaspidis (Brèth.), Arrhenophagus chionaspidis Aurv., and Apterencyrtus microphagus (Mayr) play an essential role in the population dynamics of this scale. The predatory mite Hemisarcoptes malus Schim. is of no significance.

Nuculaspis abietis (Schr.). Prioz.: Gory, June 23, 1957 (♀♀); Luzh.: Luga, July 2, 1956 (♀♀), July 4, 1956 (♀♀). Moist forests. V.-izv.: Pushkin, Aleksandrovskii Park, June 30, 1956 (♀♀). On the needles of spruce (Picea excelsa Link.) and pine (Pinus silvestris L.). Very rare. Recorded for the first time from the Leningrad region.

Diaspidiotus ostreaeformis (Curt.). Ubiquitous, in all tree-shrub associations, both dry and moist. However, it prefers well-exposed dry heathlands and heathland-pine associations, being quite rare in moist forests. On heather (Calluna vulgaris Salisb.), birch (Betula verrucosa Ehrh., B. pubescens Ehrh.), and rarely on linden (Tilia cordata Mill.). Found in forest parks and sometimes in urban plantings. The L_1L_1 and L_2L_2 of both males and females overwinter. Recorded from the northwestern USSR for the first time.

Zoogeographically the principal part of the coccid fauna of the Leningrad region consists of species widely distributed in the temperate forest belt of Europe and, probably, Siberia (in view of the almost complete lack of information on the fauna of Siberia, this has been established for only a few species); several of them extend into the Mediterranean subregion of the Palaearctic.

The coccid fauna of the Leningrad region is similar to the fauna of the mixed forests of the Latvian European type (Rasina, 1955; Borkhsenius, 1957) and the Swedish (Ossianilson, 1951). In number of species (33 for Latvia and 34 for Sweden) the Leningrad region considerably exceeds the others (with 54), but this is because it is better studied at present. Actually, the coccid fauna of Leningrad is poorer than that of the more southwestern and western Latvia and Sweden: it is not invaded by such species as Gossyparia spuria (Mod.), Pseudochermes fraxini (Kalt.), Cryptococcus fagisuga Landgr., Diaspidiotus zonatus (Frauenf.) and other. Only 15 species are recorded for the fauna of Finland (Enumeratio, 1935; Tiensuu, 1951); undoubtedly these do not exhaust the true list of species present and do not provide a proper comparison.

With regard to the distribution of coccids in the Leningrad region according to plant associations, two opposing tendencies are observed: on the one hand, their feeding and coenotic relationships are adapted almost exclusively to tree-shrub associations (exceptions are open sandy spaces along the seashore and railway embankments), the tree cover of which creates shade, of course, and on the other hand, in the north, in the Leningrad area, the coccids seek more illuminated and warmer locations as a group showing a propensity for southern latitudes and there achieving their greatest variety of form. This contradiction is resolved in the fact that the coccids select edges of forest and forests with sparse cover.

According to their plant associations the coccids are distributed in the following manner (the system of associations is that of Tsinzerling, 1932.

The principal portion of the species is associated with moist forests. The majority of these inhabit green moss and tree associations (spruce, pine, and mixed forests), that is, the most characteristic zonal elements of the region. The dominant species here are:

On trees and shrubs

Chionaspis salicis	Pulvinaria betulae
Physokermes piceae	Diaspidiotus ostreaeformis
Paroudablis piceae	Nuculaspis abietis
Phenacoccus aceris	

On heathland shrubs

Spinococcus calluneti	Eulecanium franconicum (bilberry form)

In mossy cover and rotting leaves

Newsteadia floccosa

On grasses

Luzulaspis luzulae	Rhizococcus insignis
Peliococcus balteatus	Eriopeltis rasinae
Orthezia urticae	E. plumeus

In the south of the region (Luga district) Lepidosaphes ulmi often invades the edges of the forests.

In the vegetation of complex spruce-shrub associations, pine, and mixed forests there are elements of deciduous forest (linden, maple, and hazelnut) together with elements of the green moss associations; heather shrubs, abundant in the green moss associations, are poorly developed here and even altogether absent in places; the moss cover is not thick, the grassy cover is rich and varied. These associations are most frequently situated along the slopes of river valleys; they are seldom encountered and are not zonal elements of the Leningrad region. Their fauna is very similar to the fauna of the green moss associations, but in places Eulecanium franconium and Spinococcus calluneti, associated with heathland shrubs, and Parthenolecanium corni and Eulecanium tiliae, associated with deciduous forests, enter the tree shrub stratum and P. placatus appears in the grasses.

Fragments of true deciduous forest, such as appear, for instance, in the oak forest along the banks of the Luga River in the Luzhskii region and along the shore of the Gulf of Finland at Sestroretsk, are extremely rarely encountered in the Leningrad region. Its fauna is very similar to that of the complex spruce association, but in connection with the absence of heathland shrubs Spinococcus calluneti and Eulecanium franconium disappear completely; Physokermes piceae, Paroudablis piceae, and Nuculaspis abietis, associated with conifers, are extremely rare. Instead, such specific species as Kermococcus quercus, Asterolacanium quercicola, and Coccura comari make up for this.

The fauna of the dry heathland-pine associations and the open sandy areas is poor. To these warm and highly illuminated locations are adapted species which are widely distributed in more southern areas. Greenisca glycerae, developing on the taproot of cereals, and Parthenolecanium corni, sometimes found at the root of raspberry, are associated with the open, sandy areas with sparse grass cover which are situated primarily along the shores of the Strait of Finland and Lake Ladoga and also as isolated spots among other biotopes.

Lepidosaphes ulmi, Ceroputo pilosellae, Greenisca glyceriae and the heather form of Eulecanium franconicum are characteristic of the heathland-pine and treeless heathland associations which are widely distributed in the region. Of the species common to green moss associations Spinococcus calluneti and Diaspidiotus ostreaeformis, more rarely Eriopeltis plumeus and E. rasinae, are often encountered.

The same fauna which is characteristic of the green moss association is also characteristic of the boggy sphagnun-pine association. However, in groves with very scanty tree cover, such as that by Kingisepp, we found forms characteristic of dry pine groves and heathlands such as Lepidosaphes ulmi, Ceroputo pilosellae, and the heathland form of Eulecanium franconicum. Evidently the particularly sparse tree cover here brings about the strong insolation which favors the existence of species which, in the Leningrad region, are associated with strongly illuminated and arid spots. The presence of generally heliotropic elements in the flora and fauna of the heathlands and peat bogs has already been pointed out by Fridolin (1933).

In artificial biocoenoses coccids are found in forest parks, urban parks, street ornamentals, gardens, berry cultivations, and on the vegetation of railway embankments.

Forest parks are essentially thinned out forests which existed there previously and within which only a few tree and shrub species were planted, primarily deciduous ones. Their faunistic composition corresponds with the floristic. Thus, a green moss and spruce type of fauna is typical of the Pavlovsk and Gatchina parks, whereas the fauna of Pushkin and Petrodvorets parks, like their flora, is enriched by elements from the deciduous forests (Parthenolecanium corni, Kermococcus quercus, Asterolecanium quercicola, Pseudococcus walkeri).

Street ornamental plantings, squares, and parks within the limits of the city and suburbs are completely artificial. Their grass cover is either completely absent or consists of specially seeded grass and weeds. Coccids are found here only in the tree and shrub stratum:

Widely distributed

Lepidosaphes ulmi	Parthenolecanium corni
Chionaspis salicis	Phenacoccus aceris

Locally encountered

Eulecanium caraganae	Eulecanium tiliae
Eulacaspis rosae	Pulvinaria betulae
Diaspidiotus ostreaeformis	Parthenolecanium fletcheri
Kermococcus quercus	

In orchards Lepidosaphes ulmi is found on apple, sometimes also Eulecanium mali and Phenococcus aceris; Parthenolecanium corni is found on apple and plum.

Chionaspis salicis is widely distributed on currant in berry cultivations, Parthenolecanium corni is more rarely found on currant and gooseberry and now and then on raspberry, while Phenacoccus aceris and Pulvinaria betulae are found on currant and gooseberry. Samoilovich (1955) also recorded Lepidosaphes ulmi on currant and gooseberry.

Greenisca glyceriae inhabits the vegetation of railway embankments and open sandy streches in natural habitats.

An analysis shows that the fauna of artificial biocoenoses consists principally of local species. However, species such as Parthenolecanium fletcheri, Eulecanium mali, E. caraganae, and Aulacaspis rosae are not found in nature in the Leningrad region—the extent of their ranges is further south; evidently they were introduced into the Leningrad region with material for planting.

In the Leningrad region coccids bring about a reduction in growth, the death of individual branches, and sometimes of whole plants in ornamental cultivations and parks; in berry cultivations and gardens, moreover, the yield is lowered as a result of their activities. In ornamental cultivations and parks the coccids are especially harmful. Lepidosaphes ulmi often injures cotoneaster, hawthorn, linden, and many other trees and shrubs; Chionaspis salicis often injuries mountain ash, linden, and willow; more rarely acacia suffers from infestation by Parthenolecanium corni. Locally Eulecanium caraganae damages acacia, Phenococcus aceris hawthorn, Kermococcus quercus oak, and Aulacaspis rosae wild rose.

In berry cultivations the harmful activity of Chionaspis salicis on currant is noticeable; sometimes gooseberry and currant are affected by Parthenolecanium corni.

In orchards Lepidosaphes ulmi injures apple, locally.

Of the species surveyed thirty-one develop on woody plants, twenty-two develop on grasses, and one on moss cover and rotting leaves. Of those species living on grasses an almost exclusive preference (three species are excepted) for monocotyledons is observed (cereals, sedges, and Juncaceae, especially cereals).

All species recorded for the Leningrad region develop in a single brood (the annual cycle of Orthezia urticae, O. cataphracta, Newsteadia floccosa, and Aulacaspis rosae has not been followed through). The imagines of the majority of the species associated with woody plants appear from the end of May to the beginning of June; on monocotyledons the imagines of all species appear from the end of July to August. Consequently the most appropriate time for collecting the female coccids from trees and bushes is the beginning of the summer, while from grasses it is during its second half.

Entomophages and, in certain years, climatic conditions play the essential role in the dynamics of the populations. Thus, the low numbers of Phenacoccus aceris, Eulecanium franconicum, E. douglasi, and Kermococcus quercus as well as the sharp depression in numbers of Physokermes piceae and Ph. latipes observed during recent years, may be explained as being due to the effective activities of chalcids (Chalcidoidea). Locally the predatory Chilocorus renipustalatus L. and Ch. bipustulatus L. suppress the multiplication of Chionaspis salicis. Among the other entomophages the larvae of the beetle Brachytarsus nebulosus Forst. and the fly Leucopis (Leucopomyia) silesiaca Egg., the mite Hemisarcoptes malus Schim., and the bug Calocoris biclavatus H.-S. may be mentioned.

The severe winter of 1955/1956, when during the course of 22 days the average daily temperature did not rise above −20°, caused a high mortality among many species. In Lepidosaphes ulmi, for instance, on several plant species all or almost all of the overwintering eggs located above the snow cover died, such that it was difficult to find individual live insects on plants which had been previously covered with old colonies. Parthenolecanium corni suffered an average of 64% loss of overwintering larvae. We might mention for comparison that in Chionaspis salicis, better adapted to northern conditions, only about 7% of the population died.

The early autumn frosts of 1956 caused a considerable reduction in the numbers of several species. Thus, as a result of the premature leaf fall the larvae of Parthenolecanium corni were not able to migrate from the leaves to the branches and died on the fallen leaves. In 1957 there were only a few individual insects left on previously heavily infested acacia bushes.

SUMMARY

This article is the first survey of the scale insect fauna of the Leningrad region. It summarizes the data on the distribution of the species, both geographical and among the ecological stations, on the biology and injuriousness of these species. External recognition characters are given for some species.

The investigations have been carried out in 1956-1957, partly in 1955.

The collection gathered in the course of these studies contains 52 species, of which 30 hitherto have never been found in the Leningrad region, while 7 species are quite new for the USSR. Including these species, the scale insect fauna of the Leningrad region comprises 54 species.

From the zoogeographical standpoint the bulk of the scale insect fauna of the Leningrad region is composed of species widely distributed in the forests of the temperate zone of Europe.

In the Leningrad region the scale insects are confined almost exclusively to tree-shrub associations; they avoid open sites (except sand dunes and beaches along the coasts of the Gulf of Finland and the shores of Lake Ladoga, as well as the open tracts of sand along railways) but tend to inhabit forest outskirts and sparse forests. Most species are confined to moist forests. The scale-insect fauna of dry pine forests, heaths and open sandy spaces is poor; it consists of certain species widespread in more southern regions.

Scale insects have been found in certain artificial biocoenoses, such as the parks in towns and cities and suburban parks, as well as any patches of urban greenery. They were also found in orchards and on berry shrubs. The fauna of the artificial biocoenoses has been formed by native species except Parthenolecanium fletcheri (Ckll.), Eulecanium caraganae Borchs., E. mali (Schr.) and Aulacaspis rosae (Bouché) that have been introduced by accident with planting materials from more southern regions.

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A NEW SPECIES OF THE GENUS ECLIPOPHLEPS TARB. (ORTHOPTERA, ACRIDIDAE) FROM CENTRAL KAZAKHSTAN

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The genus Eclipophleps was established by S. P. Tarbinskii in 1927 on the basis of the single species E. bogdanovi Tarb. (1927). Later G. Ya. Bei-Bienko described another species of this genus, E. glacialis B.-Bienko (1933). Finally, 2 additional species—E. similis Mishch. and E. confinis Mishch. (1951)—were described by L. L. Mishchenko in 1951. All four species mentioned are distributed in northwestern and western Mongolia.

The species described here, Eclipophleps kazacha Mal'kovskii, sp. n., was found in central Kazakhstan in 1957. The finding of a representative of this genus here is an additional example of the presence of Mongolian elements in the fauna of central Kazakhstan.

Eclipophleps kazacha Mal'kovskii, sp. n.

♂. Head short. Frontal crest feebly impressed below the median ocellus, broadened for its lower portion. Vertex broad; its width between the eyes twice that of the frontal crest between the antennae. Impressions of vertex long, somewhat narrowed apically, with sharp edges; length of impression equal to twice its width. Eyes large, broadly oval; vertical diameter of eye twice the length of the subocular groove and 1 $^1/_4$ times its horizontal diameter. Antennae slender, filamentous; their length somewhat exceeding that of the head and pronotum combined; length of one median antennal segment 2–2 $^1/_2$ times greater than its width.

Pronotum short with a distinct posterior transverse groove which extends far beyond the center of the pronotum well onto its lateral lobes; greatest width of pronotum between the lateral carinae 2 $^1/_2$ times its least width; length of anterior portion of pronotum 1 $^1/_2$ times that of its posterior portion; greatest width of posterior portion of pronotum twice its length; median carina distinct throughout its length; lateral carinae strongly arcuately curved and effaced before the posterior transverse groove; posterior margin of pronotum slightly outwardly rounded. Mesothorax with a broad interspace between the lateral lobes, which have posteriorly diverging edges; the least width of the interspace is somewhat more than twice its length and equal to the width of the lateral lobe. Metathorax with a narrow interspace between the lobes; the least width of the interspace about equal to its length. Tegmina overlapping, with broadly rounded apices, reaching the end of the anterior third of the posterior femora. Posterior femora stout, with 3 dark spots above which extend onto the outer face; femur 4 times as long as wide, its apex dark.

Hind tarsi with a long first segment; length of first tarsal segment greater than that of third (Fig. 1). Pulvillus between the tarsal claws large, wide, its length more than half that of the claws. Tympanal organ on the first abdominal tergite distinct, not greatly reduced. Cerci lamellar, laterally compressed, 2 $^1/_2$ times as long as wide (Figs. 2, 3).

♀, similar to male. Vertical diameter of eye somewhat longer than the subocular groove. Length of antennae not exceeding that of the head and pronotum combined; length of one median antennal segment 1 $^1/_2$–1 $^3/_4$ as long as wide. Pronotum with a shorter posterior portion; length of anterior portion of pronotum 1 $^1/_2$–1 $^3/_4$ that of posterior portion; greatest width of the posterior portion of pronotum 2–2 $^1/_2$ times greater than its length, its posterior margin very feebly rounded, almost truncate. Tegmina lateral, lobular, widely spaced, apically narrowed

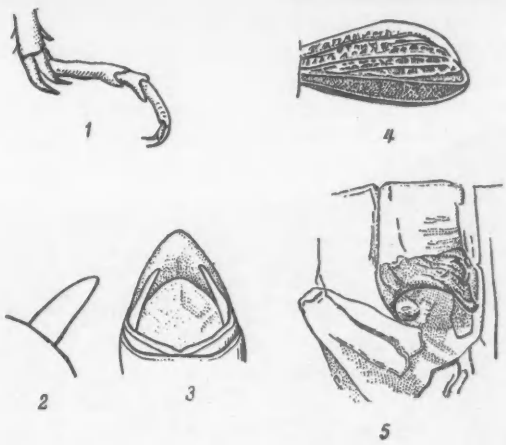

Fig. 1-5. Eclipophleps kazacha Mal'kovskii, sp. n. 1) ♂, hind tarsus; 2) ♂, cercus; 3 ♂, end of abdomen from above; 4) ♀, left tegmen; 5) ♀, first abdominal tergite and tympanal organ.

and distinctly exceeding the hind edge of the first abdominal tergite (Fig. 6); length of tegmen 2 - 2 1/2 times its width (Fig. 4). Tympanal organ distinctly visible on the first abdominal tergite, not very strongly reduced (Fig. 5). Hind margin of genital plate medially with a triangular projection.

Body length of ♂ 10.0 -10.5, of ♀ 15.0 -15.5 mm, length of pronotum of ♂ 2.0, of ♀ 2.75 mm, of tegmina of ♂ 3.75, of ♀ 2.0 - 2.5 mm, of hind femora of ♂ 6.0 - 6.5, of ♀ 7.0 - 8.0 mm, of hind tibiae of ♂ 5.0, of ♀ 6.0 to 7.0 mm.

From all other known species of Eclipophleps Tarb., E. kazacha Mal'k., sp. n. is sharply distinguished by the greater length of the tegmina of the ♀, which project beyond the apex of the first abdominal tergite, and by the lesser reduction of the tympanal organ, which is evidently associated with the greater wing length.

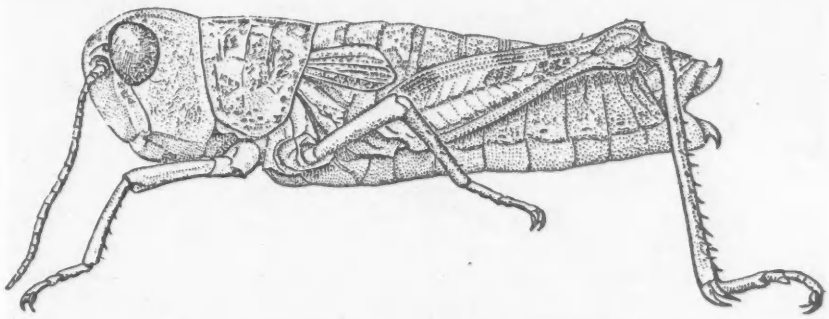

Fig. 6. Eclipophleps kazacha Mal'kovskii, sp. n., ♀.

In all the species of this genus known hitherto the tegmina of the ♀ are very short, not extending anywhere near the hind edge of the metanotum, and the tympanal organ on the first abdominal tergite is scarcely visible, being very strongly reduced. This species is closest to E. glacialis B.-Bienko; it is distinguished from the latter (as well as by the characters mentioned above) by the larger eyes in the ♂, the narrower interspace between the metathoracic lobes in the ♂, the longer metanotum in the ♂, the longer tegmina of the ♂ and the smaller body dimensions of the specimens of both sexes. In E. glacialis B.-Bienko the vertical diameter of the eye of the ♂ is equal to the length of the subocular groove, while in E. kazacha Mal'k., n. sp. it is twice as long; in the former species the least width of the interspace between the metathoracic lobes in both sexes is

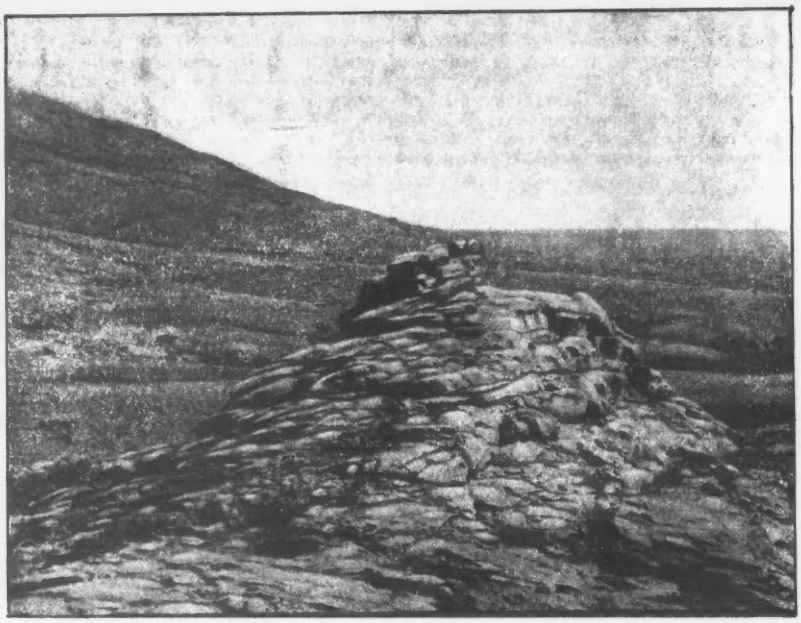

Fig. 7. General aspect of the collecting locality of Eclipophleps kazacha Mal'-kovskii, sp. n.

Fig. 8. Detail from Fig. 7.

1 ½ - 2 times its length, whereas in the latter it is almost equal to its length; in the ♂ E. glacialis B.-Bienko the length of the anterior portion of the pronotum is twice as long as the length of the posterior, while in E. kazacha Mal'k., sp. n., it is 1 ½ times as long; the length of the tegmina in the former species is 3.0 mm in the ♂, in the latter it is 3.75 mm. The body dimensions of E. glacialis B.-Bienko in the ♂ are 11.3, in the ♀ 15.0 17.4 mm; in E. kazacha Mal'k., sp. n., they are 10.0 - 10.5 and 15.0 - 15.5 mm respectively.

Collection locality. Central Kazakhstan, Karaganda region, Ulutau Mts. On rocks with sparse vegetation at 800 - 1000 m altitude (Figs. 7, 8), August 9 - 10, 1957, 2 ♂♂, including the holotype, 4 ♀♀, including the allotype (M. P. Mal'kovskii).

The types were bequeathed to the Zoological Institute, AN SSSR.

In conclusion it is my pleasant duty to extend sincerest thanks to G. Ya. Bei-Bienko and L. L. Mishchenko for providing the opportunity to compare the species described with the types of the other species of the genus Eclipophleps which are preserved in the Orthoptera section of the Zoological Institute, and for their observations made during the preparation of the present paper.

SUMMARY

The hitherto known species of the genus Eclipophleps Tarb. are distributed in northern Mongolia. E. kazacha Mal'kovskii, a new species discovered in Kazakhstan, differs distinctly from the other species by the longer elytra in the female which extend beyond the hind margin of the first abdominal tergite, as well as by the less reduced tympanal organ, which is well discernible. Among the species of Eclipophleps, E. glacialis B.-Bienko is the closest to the new species. Besides the above-mentioned characters E. kazacha differs from E. glacialis by its larger eyes, longer metanotum and elytra, narrower interspace between the metasternal lobes in the male and by the smaller body in both sexes.

Ulutau Mts., alt. 800-1000 m., central Kazakhstan, Aug. 8, 1957, 2 ♂♂ (including the type) and 4 ♀♀, on rocks.

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NEW AND LITTLE-KNOWN SPECIES OF THE GENUS ARGYROPLOCE (S. LAT.) (LEPIDOPTERA, TORTRICIDAE) FROM SOUTH SIBERIA

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Argyroploce (Phiaris) subtilana Falkovitsh, sp. n.

Moth. In color and pattern very similar to A.(Phiaris) arcuella Cl.

Wing span 11-13 mm (in males usually about 12 mm, in females a little more).

Forewings elongate-triangular, broadening slightly toward outer margin; their hind margin almost straight, outer margin oblique, apex rounded.

Color of forewings brownish orange; three short leaden silver longitudinal lines at root of wing: one on costal margin, second in middle of wing, third at hind margin. Basal third of wings marked off by a straight leaden silver crossline. Beyond center of wing, in hind half, a longitudinal black patch retaining small areas of ground color and four leaden silver dots; this patch is bounded on the side of the outer margin by a short transverse leaden silver band. Above the black patch the ground color lightens to pale yellowish and is traversed by four longitudinal streaks. On fore margin at apex of wing, pale yellow spots (costal streaks) usually three in number; from the first (preapical) of these a short leaden silver line extends obliquely in the direction of the outer margin; another such line extends from the second costal spot and traverses more than half the width of the wing. Fringe grey and lustrous.

Hindwings brownish grey with pale grey fringe.

Head and palps yellow-grey; dorsum similar in color to ground color of forewing, abdomen of same color as hindwings.

From A. arcuella Cl., which can be assigned along with closely related species to a separate genus Phiaris Hb. [Kennel, 1921], the new species differs markedly in its smaller size, the rather less bright coloration of the forewings, the yellower ground color of the paler region above the black patch, and the paler coloration of the hindwings; the pattern in the two species is the same.

Male genitalia (Fig. 1, a). Uncus broad, with emarginate apex. Penis in form of a uniformly sclerotized curved tube, with no spines on the pars inflabilis. Valvae long, narrow, their apical half curved slightly upwards and marked off from the basal half by a series of stout spines extending diagonally from the upper margin of the valva to the lower. On progression toward the apex of the valva the spines are replaced by hairs, but on the lower margin of the valva the spines, decreasing in size, continue almost to its apex. On the lower margin of the valva, under the row of spines, there is a large, dense bunch of fine hairs.

The main differences from A. (Phiaris) arcuella Cl. [Pierce and Metcalf, 1922] are that in the new species, the lower margin of the valva level with the bunch of hairs has no process (there is a barely discernible tubercle); the bunch of hairs is thicker than in arcuella, and is located directly under the row of spines (in arcuella they are closer to the center of the basal part of the valva); the penis lacks spines on the pars inflabilis; the uncus is broader.

Female genitalia (Fig. 1, b). Papillae anales broad, expanding evenly toward apices, with rounded ends. Ostium bursae with raised sclerotized rim invested with small spinules, and from the lower part of which there extends laterally on each side a small pointed sclerite. The portion of the ductus bursae adjacent to the ostium

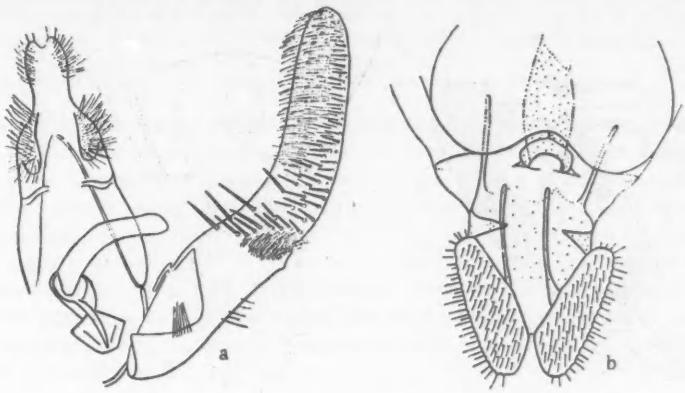

Fig. 1. Genitalia of Argyroploce (Phiaris) subtilana, sp. n. a—♂; b—♀.

is slightly swollen and sclerotized, this portion stops short of the fore margin of the seventh segment and is obliquely delimited from the membranous part of the duct. The seventh sternite has a concave hind margin and is sclerotized for the most part; the sclerotized part has round lateral margins and is covered with small spinules visible under high magnification (not shown in figure).

The main differences from A. (Phiaris) arcuella Cl. are: papillae anales in new species broader, with more rounded apices; margin of ostium bursae surrounded by a sclerotized rim (and not clavately swollen, as in arcuella); seventh sternite densely invested with very small spinules.

The species is described from 14 specimens collected in the foothills of Salair Ridge, N. Vaganovo-Kemerovo region, in 1955: 16/VI—3♂♂, 1♀; 22/VI—1♂; 23/VI—1♀ (allotype); 25/VI—5♂♂, 1♀; 28/VI—1♂ (holotype); 1/VII—1♀.

The moths appeared a little later than arcuella, about mid-June, and were often found in fairly damp birch-fir groves in the pretaiga zone. In addition, two specimens of this species (♂ and ♀) were taken on 2/VII/1956 in a marshy birch grove near Myski (flood-plain of R. Mras-Su among the spurs of the Kuznetskii Alatau).

In an examination of the collections of the Zoological Institute AN SSSR we found two females of this species: "Kislukha, Barnaul district, Tomsk, 11-18/VI/1911" and "Ussuri Terr., Suchan, Tigrovaya, 10/VII/1928 (Kurentsov)", identified by N. N. Filip'ev as "Phiaris arcuella Cl." The discovery of these two specimens, undoubtedly A. (Phiaris) subtilana, sp. n., marks the two extreme points of the present known range of this species.

Argyroploce (Endothenia) hebesana Wlk.

Recorded for Palaearctic for first time. The identification was made by comparing mounts of the genitala of Siberian and North American specimens of this species.

Among the palaearctic representatives of the Endothenia group A. hebesana Wlk. stands somewhat apart, and hence we give a description of the moth below.

Moth. Wing span 15.5-18 mm, average 17 mm.

Forewings long, rather narrow, expanding slightly toward outer margin; their hind margin gently curved, apex rounded, outer margin oblique.

Ground color of forewing greyish brown; on costal margin between transverse bands the coloration is darker, blackish brown. Transverse bands lighter than ground color, brownish grey, with uneven, sometimes diffuse outlines. Base of wing somewhat paler, but usually not very different from ground color; the transverse band marking off the basal part of wing rather broad, a little broader at hind marginal half of wing; in fresh specimens, especially in females, the costal margin of this band is sometimes lightly dusted with reddish brown, and closer to the center has a steely blue luster: the second transverse band, extending from fore margin of wing (at about $^1/_3$ wing

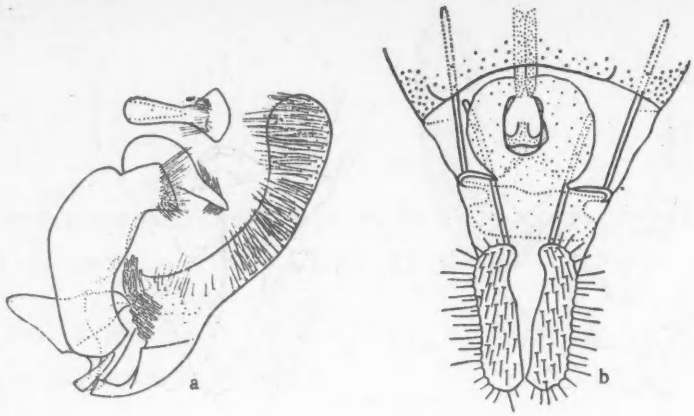

Fig. 2. Genitalia of Argyroploce (Endothenia) hebesana Wlk. a—♂; b—♀.

length from apex) to hind margin, forms a small area above center of wing jutting into the central field and gives off a branch toward hind angle; on the dorsal side of the wing between the two branches of this band there is a tiny area of dark color (pretornal spot). Costal streaks whitish, double, often indistinct at apex; space between them with an admixture of reddish brown scales. From the costal streaks there arise bands which combine to form one diffuse band extending toward outer margin; a blackish dot on apex of wing; preapical spot usually in form of a curved dark band, with the arch toward the apex. Fringe dark with steel-blue luster, greyish white at hind angle.

Hindwings dirty or brownish grey, paler towards base of wing (especially in males); fringe whitish.

Head and palps brownish grey dorsum of same color, with reddish brown tufts. Abdomen brownish grey.

Male genitalia (Fig. 2, a). Tegumen well developed, broad; uncus in basal part laterally constricted, hollow below, protruding above tegumen in the form of a round crest, and dorsoventrally flattened in terminal part, invested with setae above, and with a row of spines on margin below. Penis short, roughly triangular in form, with concave upper margin; beak-like at end, membranous below and a little on the right, without spines on pars inflabilis; fultura inferior very narrow. Valvae with dilated basal part, constricted in middle, roundly expanded toward apex. On inner surface of valva, close to its base, a process projecting over the upper margin of valva and covered with short, stout blunt-tipped spines; below this formation part of the valva from the lower margin is slightly raised to form an area, the sides of which converge at an angle beneath the above-mentioned spiny process.

Female genitalia. (Fig. 2, b). Papillae anales narrow, produced, expanding very slightly toward apex, with rounded ends. Eighth segment dorsally sclerotized; from this sclerite narrow extensions bend around fore margin on each side on to sternite; remainder of sternite membranous. From these extensions, representing the sclerotized margin of the eighth segment there arise the apophyses anteriores, which are almost indistinguishable in length from the apophyses posteriores. Ostium bursae longitudinally produced, rimmed by a flat sclerotized elevation and surrounded by an indistinct, rounded, yellowish hyaline intersegmental sclerite. Ductus bursae narrow, the portion adjacent to ostium sclerotized, but over whole length of this portion there remains a narrow dorsal membranous clear space. Seventh sternite membranous.

Seventeen specimens of this species were collected by the author in the environs of Myski, Kemerovo region (spurs of Kuznetskii Alatau) in 1956.

From mid-June onwards we found only spent females. The months were fairly common in the flood-plain of the R. Mras-Su, in glades in the taiga and on the slopes of small hollows.

This species would appear to be distributed throughout south Siberia and the Far East Territory; in the collection of the Zoological Institute AN SSSR we found one female A. hebesana Wlk. from Kuldja (west Sinkiang) and a spent male of this species, incorrectly identified by N. N. Filip'ev as Argyroploce textana H. G. with the label "Vinogradovka, Ussuri Terr., 27/VI/1929, D'yakonov, Filip'ev".

Argyroploce aviana Falkovitsh, sp. n.

Moth. Wing span 13-15 mm (usually 14 mm in male, a little larger in female).

Forewings broad, with curved fore margin and almost straight hind margin.

Ground color of forewing rusty brown of various shades; on examining the wing under a binocular we see that this color is produced by rufous scales with black scales scattered among them. Pattern: part of wing at base differing in color; a transverse band bounding basal third of wing: a second transverse band, distinctly curving toward outer margin, extending from fourth pair of costal streaks and reaching hind margin of wing between first band and hind angle; the other branch of this band, directed toward hind angle, is somewhat isolated; the three preapical costal streaks of yellowish color, double, give off bands which fuse into one indistinct band directed toward outer margin. Transverse bands indistinct, formed by scattered yellowish scales, there being a very characteristic fairly large admixture of leaden blue scales, sometimes completely obliterating the pale ground color of the bands. Fringe rufous-yellow; near center of outer margin the scales have black tips; at base of fringe a distinct rufous-brown line.

Hindwings dark, brownish grey with a dirty or yellowish white fringe.

Palps rufous-yellow, head and dorsum of rusty brown color, tuft of metanotum darker; abdomen of same color as hindwings.

Male genitalia (Fig. 3, a). Uncus broad, with rounded apex; penis rather broad, slightly bent downward and to the right, with spines on the pars inflabilis. Valvae with notch on lower margin, so that the cucullus is distinct, broad at base, slightly swollen and invested with stout spines, extending further along lower margin of valva, but not reaching its apex; rest of cucullus, which narrows toward apex, covered with hairs.

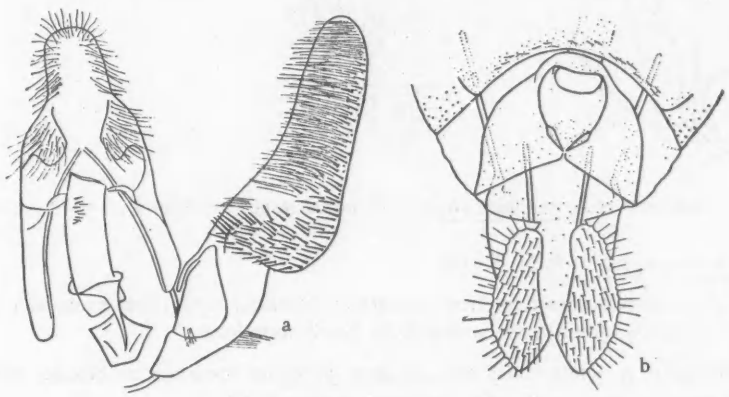

Fig. 3. Genitalia of Argyroploce aviana, sp. n. a— ♂; b—♀.

Female genitalia (Fig. 3, b). Papillae anales of foot print form. Ostium bursae opening in a funnel-shaped expansion; in hind part of expansion its edges are thickened, and the general outline is almost heart-shaped. Merging with the rim of the ostium are the bases of two broad triangular sclerites with apices directed caudad and laterad and reaching margins of eighth segment. Part of ductus bursae adjacent to ostium weakly sclerotized and distinctly bent (in correspondence with the structure of the male copulatory organ).

Seventh stemite weakly rugose along arcuately excised hind margin; toward fore margin of stemite the sclerotization disappears. Bursa copulatrix with small flat plate of rounded form (sometimes with uneven edges).

It is difficult to relate A. aviana sp. n. directly with any other species of the genus Argyroploce. In external characters this species is similar to A. obovata Wals., but the brevity of the description [Walsingham, 1900] does not permit a more definite conclusion without an examination of the genitalia of the species mentioned.

The description was made from 18 specimens collected in the environs of Myski (spurs of Kuznetskii Alatau) in 1956: 9/VII–1 ♂ ; 11/VII–1 ♂ (holotype); 13/VII–1 ♀ ; 14/VII–1 ♀ ; 15/VII–2 ♂♂ , 2 ♀♀, 16/VII– 1 ♂, 1 ♀; 20/VII–1 ♂ , 1 ♀ (allotype); 21/VII–1 ♂; 23/VII– 2 ♂♂ , 1 ♀ ; 24/VII–1 ♂ ; 11/VIII–1 ♀.

After mid-June we found only spent specimens. The months were found in an unflooded part of the floodplain of the R. Mras-Su, always on Spiraea bushes, with which this species is probably associated in its biology.

In describing A. aviana sp. n. we used, besides the material from South Siberia, specimens from the Far East (1 ♀, Suchan, Primor'e Territory, 19/VIII/1928, Kurentsov; 1 ♂, Klimoutsy, Amur region, 20/VII/1958, Kuznetsov).

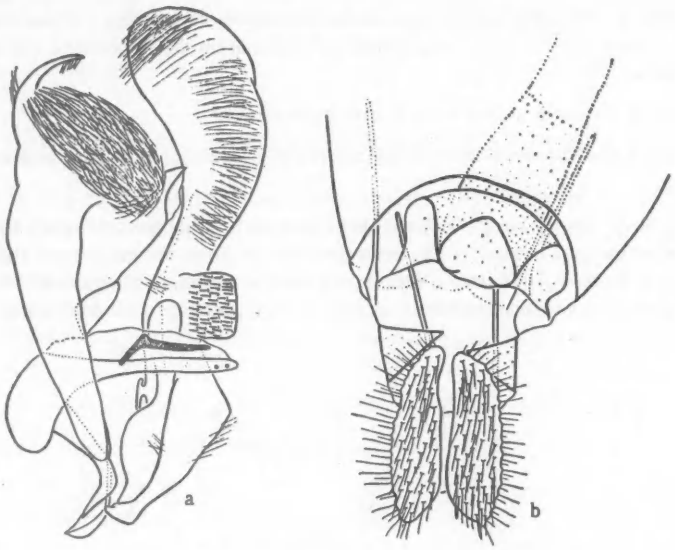

Fig. 4. Genitalia of Argyroploce (Apotomis) infida Heinr. a– ♂; b–♀.

Argyroploce (Apotomis) infida Heinr.

The identification of this species, described from N. America [Heinrich, 1926], was made from the figure of the female genitalia of A. infida, given by the author of the first description.

Moth. Outwardly similar to A. semifasciana Hw., but in A. infida the forewings are broader, their coloration greyer, and the outer marginal field much paler (from grey to dirty white).

The male genitalia, (Fig. 4, a) is characterized mainly by the squarish spinose process of the valva, the angular projection of the lower margin of the basal part of the valva and the straight terminal part of the penis.

The female genitalia (Fig. 4, b) differs from that of A. semifasciana Hw. in the absence of swelling in the portion of the ductus bursae adjacent to the ostium and the distinctive structure of the roundly triangular ostium with the intersegmental sclerite adjacent to it.

One female of this species was found on 26/VI/56 in a willow grove on the banks of the R. Mras-Su near Myski.

Several examples of A. infida Heinr. were also collected in 1953-1954 in the environs of Leningrad.

Obviously A. infida Heinr. is a widely distributed species which has been confused with A. semifasciana Hw.

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THE SPECIES OF THE GENUS PTEROPTRIX WESTW. (HYMENOPTERA, APHELENIDAE) IN THE USSR

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The species of Pteroptrix Westw. are parasites of coccids of the family Diaspididae and have a worldwide distribution. In the USSR 4 species have been reared at present, of which P. longicornis, sp. n., was contemplated for description in 1954 and mentioned by B. M. Chumakova (1957), who reared it from Diaspidiotus gigas (Thiem et Gern.) in the Primor'e territory.

In recent years new species of Pteroptrix have been described: P. caucasica Yasnosh (1955), P. opaca Erdös (1956), P. callunae Mashhood, and P. zonatus Mashhood (1956). Dr. Huba (1957) mentions having found the common European species P. dimidiata Westw. among some parasites of the California scale in Czechoslovakia, but on visiting the Zoological Institute, AN SSSR, he personally communicated his finding of yet another species, possibly identical to the one here described.

Pteroptrix longicornis Nikolskaja, sp. n.

Female. Antennae long (Fig.1, a), with sparse setae, the segments of the funicle (2, 1.5, 2.5) and club long; 1st funicular segment somewhat longer than the 2nd, the 3rd a little longer than the 1st, and the club approximately 2.6 times longer than the segments of the funicle (8, 3). Pronotum with 2 - 3 bristles on the sides. Anterior wings with a fine fringe of long hairs (Fig. 1, c), 5 bristles along the edge of the marginal vein, and 2 - 5 shorter ones along the edge of the wing above the submarginal vein. The protruding portion of the ovipositor is long, nearly equal in length to the first two segments of the hind tarsi. Body and venation of the fore wings dark brown, head above and anteriorly reddish, lobes bordering the mesonotal scutum, and scutellum, yellow, antennae brownish, coxae and femora darkened, tibiae and tarsi whitish. Fore wings below the marginal vein fuscous.

The male differs from the female in the form of the abdomen, by the somewhat longer and wider fore wings, and by the longer and stouter yellowish antennal flagellum (fig. 1, b) with an annular 2nd segment (5, 1, 5).

Measurements	Females	Males
Body length	0.73-0.92 mm	0.73-0.92 mm
Length of fore wing	0.53-0.71 mm	0.62-0.76 mm
Width of fore wing	0.18-0.25 mm	0.23-0.29 mm
Maximum length of the fringe on the fore wing	0.09-0.11 mm	0.09-0.11 mm
Length of antennal flagellum	0.37-0.49 mm	0.45-0.56 mm
Length of club	0.22-0.33 mm	0.25-0.30 mm
Length of ovipositor	0.07-0.09 mm	–

This species differs from P. dimidiata Westw. by its greater average size, longer fringe on the fore wings, longer antennal funicle with a longer club and funicular segments, and the significantly greater length of the protruding portion of the ovipositor.

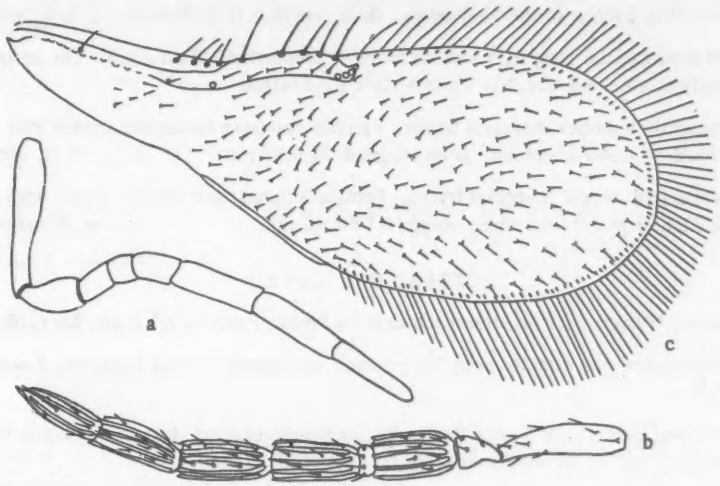

Fig. 1. Pteroptrix longicornis, sp. n. a—antenna of female; b—antenna of male; c—fore wing.

14 males, the allotype among them, and 20 females, the holotype among them, were reared from Diaspidiotus gigas (Thiem et Gern.) in Kislovodsk on May 25, 1948, by V. V. Smol'yanikov and are located in the collection of the Zoological Institute, AN SSSR.

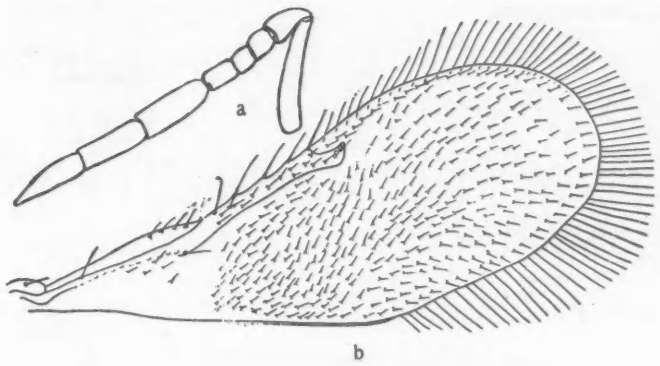

Fig. 2. Pteroptrix maritima Nik. a—antenna of female; b—fore wing.

Distribution. Crimea, Northern Caucasus, Primor'e territory.

Biology. Parasitizes Diaspidiotus ostreaeformis (Curt.), D. gigas (Thiem et Gern.), D. perniciosus (Comst.), D. spurcatus (Sign.), Aulacaspis mali Borchs., Chionaspis syringae Borchs., Leucaspis japonica Ckll.

KEY TO THE SPECIES OF PTEROPTRIX WESTW.

1 (2). Fore wings with dense and short ciliation. Marginal vein but slightly thickened, radial vein longer than wide (Fig. 2, b). Funicle joints densely pubescent (Fig. 2, a). Scutum with 3-4 bristles on each side. Body length 0.54-0.75 mm . . . . . 1. P. maritima Nik.

2 (1). Fore wings more sparsely ciliate. Marginal vein thickened, radial short. Funicle joints not densely pubescent. Scutum with 2-3 bristles on each side.

3 (4). Female antennae long with funicle joints in proportion 2 : 1.5 : 2.5. The protruding part of the ovipositor equal to the first 2 joints of the hind tarsus. Body length 0.73-0.92 mm . . . 2. P. longicornis, sp. n.

4 (3). Female antennae not long with funicle joints in proportion 1.5 : 1 : 1.5. The protruding part of the ovipositor distinctly shorter than the first 2 joints of the hind tarsus.

5 (6). Fore wings with shorter marginal fringe. Female antennae somewhat shorter with shorter club. Tip of the ovipositor hidden under abdomen. Body length 0.63-0.86 mm . . . . . 3. P. dimidiata Westw.

6 (5). Fore wings with longer marginal fringe. Female antennae somewhat longer, with longer club. Tip of the ovipositor slightly protruding. Body length 0.70-0.92 mm . . . . . 4. P. caucasica Jasnosh.

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A NEW SPECIES OF CULICOIDES LATR. (DIPTERA, HELEIDAE) FROM THE ARAKS VALLEY

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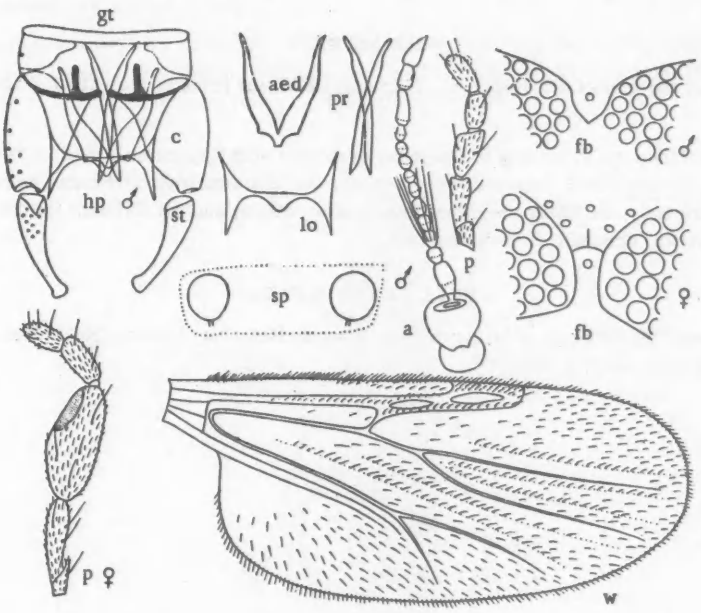
During a study of the biting midges of the Araks Valley in the Nakhichevan' ASSR one new species of Culicoides was discovered. Its description is presented here.

Culicoides flavidus Dzhafarov, sp. n.

This species belongs to the group of species with unmarked wings. It is most closely related to C. firuzae Dzhaf., which was described from the same region. A characteristic difference is the pale yellow coloring of the entire body, including the mesonotum and scutellum, and the different structure of the male hypopygium.

Female. Wing length 1.3–1.4 mm.



a–Antenna (7 × 18); p–palpus (7 × 40); fb–frontal band; w–wing (7 × 8); sp–spermathecum; 9t–9th tergite; hp–hypopygium; lo–lateral outgrowths; c–coxite; st–stylus; pr–parameres; aed–aedeagus.

Head. Eyes not contiguous. Frontal band of moderate width, without minute setae; its width equal to the the diameter of a facet. Upper transverse suture arcuate. Longitudinal suture distinctly evident, short. Lower transverse suture lacking. Palpi, with the 3rd segment large, 3 times as wide and 1 ½ times as long as the 2nd, elongate-oval in form; sensory organ shallow, elongate-oval.

Thorax. Mesonotum and scutellum dark yellow, unmarked. Halteres yellowish white. Wings unmarked, opaque white. Macrotrichia short and sparse, covering the entire wing, few in number on the basal cell (2-3). First radial cell shorter than the second. Legs yellowish brown. Abdomen pale yellow. Two spermatheca, very small, globose and weakly sclerotized. They are located in parallel along the sides of the hind end of the abdomen.

Male. Coloration like that of female.

Head. Frontal band—see figure. Antennae. Third segment longer than the 4th and 5th combined. Length 3 segments considerably longer than the preceding. 13th segment 1 ½ times longer, but more slender, than the 14th. Apical segment conical. Palpi, lengths of 2nd and 3rd segments equal, the width of the latter greater than that of the 2nd; sensory organ very weakly developed, minute and rounded.

Thorax. Mesonotum and scutellum like those of female. Wings narrower. Legs dark yellow.

Hypopygium. 9th tergite comparatively short, about twice as wide at the base as at the apex; posterior margin convex, without excisions. Lateral outgrowths well developed, long and slender. Coxite distinctly narrowing apically, its ventral appendage boot-shaped with a stout digitate apex; the ends of the appendages are approximated. Styli broad at the base, slightly curved at the middle, and widened apically. Parameres linear, narrowing toward both ends, the anterior margin ending in a minute hooked appendage. The aedeagus is deeply divided. The height of the arc is somewhat greater than its width.

Distribution. Nakhichevan'ASSR: Ordubad station, May 26, 1954, 1♀; Nakhichevan', July 1, 1954, 1 ♂. Both specimens collected on light. The types are deposited in the Institute of Zoology, AN AzSSR, Baku.

SUMMARY

A new species of the genus Culicoides Latr., (Diptera, Heleidae) found in the valley of the Araks river is described.

C. flavidus Dzhafarov, sp. n. belongs to the group of species with nonspotted wings. It is similar to the recently described C. firuzae Dzhaf. from the same locality, the characteristic differences being the light yellow color of the entire body, including the mesonotum and scutellum, and the different structure of the male hypopygium. Distribution: Ordubad, S. Transcaucasia.

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A NEW PALAEARCTIC GENUS AND SPECIES OF CHLOROPIDAE (DIPTERA)

E. P. Narchuk

During an examination of the collection of Chloropidae in the Zoological Institute, AN SSSR, one specimen (a female) of Chloropinae was discovered which differed strongly from all known genera of this subfamily. During field work in central Kazakhstan in the summer of 1957 the author collected 4 more specimens (2 ♂♂ and 2♀♀) of this same species, which is here described as new and which is separated into a new genus—Platycephalisca. Among all the known genera of this subfamily the new genus differs in showing sexual dimorphism in leg structure.

In the shape of the head and the vertical triangle the new genus is closest to the neotropical genus Leptotrigonum Becker, 1912, but differs in the absence of punctures on the vertical triangle, in the structure of the antennae (the third segment is of different shape), and in the presence of a strong carina separating the antennal insertions.

In general appearance and antennal structure the new genus is very similar to several species of Pachylophus Loew, 1858, which occur in the Ethiopian and Oriental regions, but its arista is not apical and, besides, it differs in the structure of the hind legs.

In head structure (with its strongly forwardly projecting frons and backwardly sloping face) the new genus approaches the generic group Eurina Meigen, Trichieurina Duda, and Platycephala Fallén, but in general appearance and several other features it is very different from these.

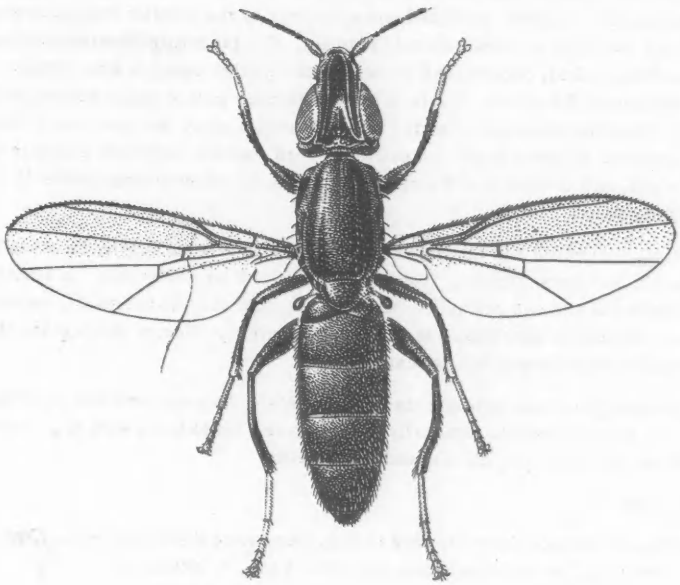

Fig. 1. Platycephalisca nigra, sp. n., ♂.

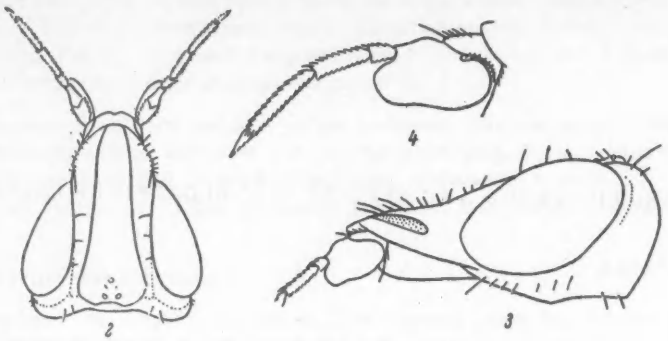

Fig. 2–4. Platycephalisca nigra, sp. n. 2) dorsal view of head; 3) lateral view of head; 4) antenna.

Platycephalisca Nartshuk, gen. nov.

Slender with somewhat elongate body. Frons projecting far behond the level of eyes. Face retreating, head profile triangular. Face with a large conspicuous sharp median keel separating bases of antennae. Eyes bare with the long axis nearly horizontal. Third antennal segment elongate-oval. Arista thickened with short and dense hairs. Cephalic bristles weakly developed. Humeri conspicuously drooping, consequently anterior part of thorax appearing somewhat elevated. R_{2+3}, R_{4+5} and M erect, not curved toward anterior margin of wing. Cross veins not approximated. Male with fore and hind femora slightly thickened; tibia not curved. Female with legs not modified as in male.

Platycephalisca nigra Nartshuk, sp. nov.

Male, female. Entirely black. Head broader than thorax. Frons dull, projecting beyond the level of the eyes for a distance equal to one half the length of the long axis of the eye, 2 $^1/_2$ times longer than broad, shaped anteriorly like a truncated triangle, and provided laterally with minute black bristles (Fig. 2). Frontal triangle smooth, shining, narrow, long, slightly depressed and extending to the anterior margin of the frons. Outer vertical bristles shorter than the width of third antennal segment. Orbital bristles shorter than the outer vertical ones, three on either side. Postvertical, ocellar, and inner vertical bristles equal in size, minute and hairlike, much shorter than the orbital ones. Eyes bare. Parafacialia and anterior part of genae narrow, only slightly exceeding one half the width of the third antennal segment. Genae brownish along the eyes, conspicuously dilating posteriorly (Fig. 3). 2nd antennal segment expanded outwardly, 3rd segment brownish, elongate-oval (Fig. 4). Arista black, densely pubescent, and divided into 3 distinct segments, its extreme apex (about $^1/_6$ of the length) tapering and white or slightly paler.

Mesonotum finely sculptured and consequently subopaque, flattened before the scutellum. Pilosity of mesonotum black, even, and inconspicuous. Notopleural bristles 2 on either side. In addition to these, there is one prescutellar dorsocentral and one postalar bristle on each side. Scutellum small, rounded, somewhat longer than wide at the base. Apical bristles black, shorter than scutellum. Pleurae shining and finely sculptured like disc of thorax. Hypopleurae and scutellum beneath dusted.

Legs black, excluding tarsi and extreme tip of tibia. Male femora, both fore and hind (latter only at base), thickened (seeFig. 1). Wings brownish, especially behind costa. Costa fused with R_{4+5} near wing apex. Halteres black. Abdomen black, dulled by greyish dust and black hairs.

Length about 5 mm.

Gremyachka, Ryazan district, May 23, 1909 (♀) (A. Semenov); Kokshetau Mts., Akmolinskaya region, June 7, 1957 (2 ♂♂, including the holotype), June 30, 1957 (♀) (E. P. Narchuk).

The types are in the collection of the Zoological Institute, AN SSSR, in Leningrad.

All specimens from Kazakhstan were collected in very humid spots, in sedge growth. In the Kokshetau and Kent mountains they were associated with meadows with underground water springs and the boggy margins of streams in lowland areas.

The illustrations were made by the artist L. V. Chernysheva.

CHRONICLE

ACCOUNT OF THE WORK OF THE ALL-UNION ENTOMOLOGICAL SOCIETY UNDER THE ACADEMY OF SCIENCES, USSR, FOR 1958

In its work for 1958 the All-Union Entomological Society (VÉO), under the Academy of Sciences of the USSR, endeavored to promote the fulfillment of the historical tasks set before Soviet entomologists by the 20th Congress of the CPSU in the field of agriculture and cultural construction, aimed at raising the theoretical level of research and leading it toward the solution of practical problems.

Organizational activity. On January 1, 1958, the All-Union Entomological Society included 1461 active members (including 8 honorary members: Prof. E. G. Bekker, V. N. Beklemishev, member of the Academy of Medical Sciences, USSR, Prof. I. V. Vasil'ev, Ya. P. Vlasov, doctor of biological sciences, Prof. A. N. Kirichenko, Acad. E. N. Pavlovskii, Prof. S. S. Chetverikov, and Prof. A. A. Shtakel'berg) and 75 competitive members.

In 1958, 121 members and 15 competitive members were accepted. As honorary members of the Society meritorious elder Soviet entomologists were selected: E. V. Zverezomb-Zubovskii (Kiev), vice president of the Society and member of the AN, UkSSR, L. P. Kalandadze (Tbilisi), Chairman of the Georgian Section of the Society and member of the Acad. Agric. Sci., Georgian SSR, Prof. A. I. Kurentsov (Vladivostok), Prof. S. G. Lepneva (Leningrad), Prof. V. I. Plotnikov (L'vov), and Prof. D. M. Fedotov (Moscow), Honored Scientist.

During the time elapsed the Society suffered severe losses with the passing of 17 members, including the honorary member Ya. P. Vlasov (Ashkhabad), prominent investigator of the natural history of Turkmenia, I. V. Kozhanchikov (Leningrad), one of the most versatile and active entomologists of our nation, V. B. Dubinin (Leningrad), the great specialist on mites, I. D. Belanovskii and V. V. Sovinskii (Kiev), senior Ukrainian entomologists, B. V. Lototskii (Stalinabad), entomologist and parasitologist, and others. Through the prolonged nonpayment of membership dues and dereliction of association with the Society, or through their own desire, 67 persons were removed from membership in the Society.

On January 1, 1959, the Society numbered 1498 members (including 13 honorary members) and 90 competitive members.

On January 1, 1959, the All-Union Entomological Society had 16 sections: the Moscow (chairman—Prof. D. M. Fedotov), Ukrainian (E. V. Zverezomb-Zubovskii, corr. memb. AN SSSR), Georgian (L. P. Kalandadze, memb. Acad. Agric. Sci., Georgian SSR), Uzbek (Prof. V. V. Yakhontov, memb. AN UzSSR), Siberian (A. I. Cherepanov, Dr. Biol. Sci.), Kazakh (Prof. P. A. Polozhentsev), Rostov (V. P. Romanova, Candidate Agric. Sci.) Moldavian (Prof. Ya. I. Prints), Ivanov (N. V. Khelevin, Candidate Med. Sci.), Sochi (K. M. Shishov), Kirgiz (vacancy), Turkmenian (A. N Luppova, Candidate Biol. Sci.), and Sakhalin (N. A. Violovich, Candidate Biol. Sci.); the latter was organized in 1958. Several of these, the Ukrainian and Siberian sections, for instance, have a number of affiliations in their turn. A Far Eastern Section is in a state of formation (chairman of the section organizational committee—Prof. A. I. Kurentsov).

In 1958, 7 meetings of Society members were held in Leningrad during which 12 scientific talks were heard. 25 to 65 persons attended the meetings.

The following papers aroused particularly lively discussions: that of G. A. Viktorov "On the origin of parasitism in hymenopterous insects", that of K. I. Larchenko on "The characteristics of development and reproduction of the mallow moth in Uzbekistan", and those of L. V. Panfilov ("Insects of the tropical forests of southwest China—geoecological outline") and O. L. Kryzhanovskii ("On the problem of the zoogeographical nature of the entomofauna of southwest China"), which were presented at one session.

Lively interest was aroused by talks devoted to the results of the travels of Soviet scientists to London for the 15th International Congress of Zoology by Acad. E. N. Pavlovskii—"15th International Congress of Zoology in London", D. M. Shteinberg—"Entomology at the 15th International Congress of Zoology", and G. Ya. Bei-Bienko, member AN SSSR,—"The antilocust center in London and its work".

On May 14, 1958, together with the Leningrad Society of Naturalists and the biological faculty of Leningrad University, a session took place devoted to the memory of the former vice-president of VÉO, Prof. B. N. Shvanvich. Prof. D. M. Fedotov gave a talk on the life and work of the deceased, while Prof. A. A. Lyubishchev, R. L. Berg, and others, reminisced.

On April 9, 1958, the traditional 11th reading devoted to the 100th anniversary of Prof. N. A. Kholodkovskii took place. The following talks were heard: M. S. Gilyarov, "Comparative evolutionary analysis of the methods of fertilization in arthropods", I. V. Kozhanchikov, "On the problem of the significance of food components in the formation of biological forms", and V. Ya. Podolyan, "The effect of gramma rays on insects".

The Council (Soviet) and Presidium of the Council held 5 sessions. Among other questions the following were discussed: confirmation of the newly organized Sakhalin Section, reorganization of the West Siberian Section into the Siberian one, preparation for the 4th (jubilee) session of VÉO and the selection of an organizational committee for the session, editing and confirmation of the publications of the Society, selection of honorary members for the Society, reception into the membership of the Society, and several other questions.

The vice-president of the Society, G. Ya. Bei-Bienko, corr. memb. AN SSSR, gave a talk at the meeting of the Section on Biological Sciences, AN SSSR, on the organization of the 4th (jubilee) session of VÉO in Leningrad in January and February, 1960.

The Section on Biological Sciences resolved that it be considered necessary to convene the 4th (jubilee) session of the All-Union Entomological Society in Leningrad in 1960 and confirmed the nomination to the Organizational Committee of the session of Acad. E. N. Pavlovskii—Chairman, G. Ya. Bei-Bienko, corr. memb. AN SSSR—alternate chairman, V. V. Popov (Leningrad), corr. memb. AN SSSR, E. V. Zverezomb-Zubovskii (Kiev), corr. memb. AN UkSSR, Kh. M. Khaberman (Tallin), member AN ESSR, L. P. Kalandadze (Tbilisi), corr. memb. AN GruzSSR, N. G. Olsuf'ev (Moscow), corr. memb. AMN SSSR, D. M. Fedotov (Moscow), Honored Scientist, M. N. Narzikulov (Stalinabad), corr. memb. AN Tadzh SSR, Prof. E. S. Smirnov (MGU, Moscow), Prof. M. E. Ter-Minasyan (Leningrad), Prof. D. M. Shteinberg (Leningrad), Prof. M. S. Gilyarov (Moscow, IMZh* AN SSSR), Prof. V. N. Stark (Leningrad, VIZR), Prof. V. N. Shchegolev (Leningrad, LSKhI**), Dr. Biol. Sci. A. V. Gutsevich (Leningrad, VMA), Dr. Biol. Sci. A. I. Cherepanov (Novosibirsk), Prof. V. V. Yakhontov (Tashkent), Candidate Biol. Sci. O. M. Martynova (Moscow), Candidate Biol. Sci. E. M. Shumakov (Leningrad, VIZR), Candidate Biol. Sci. A. F. Kryshtal' (Kiev), Candidate Biol. Sci. A. K. Zagulyaev (Leningrad), Candidate Biol. Sci. O. L. Krizhanovskii (Leningrad)—Secretary, Candidate Biol. Sci. E. P. Narchuk—alternate secretary, and Candidate Biol. Sci. M. M. Loginova—alternate secretary.

The membership of the Presidium of VEO is: President of the Society—Acad. E. N. Pavlovskii (chief editor of the Society publications); vice-presidents—G. Ya. Bei-Bienko, corr. memb. AN SSSR (editor of the "Trudy" of VÉO), E. V. Zverezomb-Zubovskii, corr. memb. AN UkSSR; members of the Presidium Dr. Biol. Sci. D. I. Blagoveshchenskii (treasurer of VEO), Prof. A. N. Kirichenko (scientific librarian of VEO), V. V. Popov, corr. memb. AN SSSR, Prof. M. E. Ter-Minasyan, Prof. A. A. Shtakel'berg (editor of the journal "Entomological Review", Prof. D. M. Shteinberg, Candidate Biol. Sci. E. M. Shumakov; scientific secretary—Candidate Biol. Sci. O. L. Kryzhanovskii.

We may here point out the extensive work carried out by VÉO, and especially by the technical secretary E. A. Buktevish, in registering the members of VÉO and in liquidating part of the previous debt in membership dues.

Publication activity. In 1958 publications work remained one of the most fundamental of Society activities.

During the year the 37th volume of the "Entomological Review" saw light (4 issues with an over-all volume of 60 quires), the 46th volume of the "Trudy Vsesoyuznogo Éntomologicheskogo Obshchestva" (24 quires), and 2 issues of the popular series appeared.

* IMZH—Institute of Animal Morphology.

** LSKhI—Leningrad Agricultural Institute.

In the "Entomological Review" for the year, 93 papers by 105 authors were published; these may be arranged by subject matter as follows: 10 works devoted to general problems in entomology, 4 devoted to anatomy, morphology, and embryology, 46 devoted to biology (including 11 on agricultural pests, 7 on forest pests, 11 on insects of medical and veterinary importance, and 8 on biological methods of pest control), 8 devoted to faunistics and zoogeography, and 33 devoted to systematics.

Of these papers 40 originated in Leningrad, 15 in Moscow, 4 each in Kiev and Khar'kov, 3 each in Irkutsk and Petrozavodsk, 2 each in Alma-Ata, Novosibirsk and Bork (Yaroslav region), and 1 each in Bryansk, Erevan, Ivanov, Krasnodar, Kuibyshev, Poltava, Stalinabad, Tashkent, Ternopol, Tbilisi, Tomsk, Ufa, Warsaw, and Helsinki.

Aside from scientific papers, 8 communications were presented in the "Chronicle" section, which discussed the activities of the All-Union Entomological Society and its sections, the work of the editorial board of the "Entomological Review", summaries of the work of the 3rd All-Union Entomological Conference in Tbilisi and other All-Union conferences, and also the work of entomologists in the countries of the people' democracies (GDR, RPR). Unfortunately, the publications of reviews of new works in the "Critique and Bibliography" section could not be carried out in 1958.

The editors of the "Entomological Review" presently have on hand 157 papers amounting to approximately 130 quires, which considerably exceeds the pagination of the journal for two years. Thus, the situation with regard to publication in 1959 continues to be extremely serious. It is urgently necessary to increase the volume of the "Entomological Review" to 6 numbers per year and 90 quires.

In the 46th volume of the "Trudy Vsesoyuznogo Éntomologicheskogo Obshchestva" 4 major works were published, including the monograph of I. A. Chetyrkina on "The Italian locust in eastern Kazakhstan".

The 47th volume of the "Trudy VEO" has been delivered to the printers. The Society possesses the manuscripts for two more "Trudy" volumes.

In the popular series the following books were put out: K. A. Breev and L. V. Savel'ev "The Reindeer Warblefly and Its Control" (5.5 quires) and A. K. Zagulyaev "Moths—Pests of Furs and Wool and Their Control" (10 quires).

On the whole, although about 100 quires were published by the Society during the year, the amount on hand in the editorial portfolio continues to greatly exceed the capacity for publication. Therefore, the Presidium of VÉO considers it essential greatly to expand publication activity in the future.

Activities of the Society Library. The library of the All-Union Entomological Society is the largest library in the USSR specializing in the field of entomology.

On January 1, 1958, the Society Library numbered 52,614 units. During the past year this became augmented through subscription, purchase, and receipts from authors, and also through exchanges with Soviet and foreign scientific institutions. The latter was carried out both through the Library of AN SSSR and directly.

In 1958 the Library was increased by 1,456 units (330 more than the preceding year), including: 610 units through direct exchange, 442 units from the AN Library through the exchange stock, 65 from subscriptions, 48 through purchase, and 291 received gratis from authors. Of these 1,456 units 400 were monographs and 1,056 were periodicals. From Soviet literature 357 units were received, from foreign literature—1,099 units.

To all authors who sent their works gratis to the Society Library the Presidium of the Society extend their sincere thanks.

1958 was distinguished by some acceleration in direct exchanges between the Society publications and those of scientific institutions in foreign countries. At the present time direct exchange is carried out with more than 45 scientific institutions and societies in 27 countries of the world, including England, Belgium, Hungary, Holland, GDR, GFR, India, Spain, Canada, Chinese People's Republic, Poland, United States, France, Czechoslovakia, Sweden, Japan, and others. In addition, the Society undertakes exchanges through the Library of the Academy of Sciences, USSR, with 20 scientific institutions in 15 countries, including Austria, Denmark, Italy, Norway, Rumania, and Finland. Altogether, exchanges are made with 66 scientific institutions and societies in 34 countries.

In connection with the extensive repairs carried out on the premises of the Zoological Institute, AN SSSR, where the Library of the Society is located, part of the stock of the Library was transferred to a hall in the Zoological Museum, where the use of books is made very difficult. However, the Library continued to conduct normal activities in the service of readers, both members of the Society and nonmembers, including numerous visiting specialists, students, etc. Altogether the Library was used by 200 persons (including 74 from out of town), the attendance was 2,175; 8,364 books were loaned out (including 47 on interlibrary loan with the Library of AN SSSR, the Saltykov-Shchedrin State Public Library, and several other libraries).

In 1958 an alphabetical card catalogue was compiled of the papers which have appeared in the publications of the Society from 1910 to 1958.

Works of the sections. The round of duties demanded of the Soviet entomologists by the life of our country is becoming ever wider and more diverse. This leads to the steady growth of entomological personnel, especially in outlying areas, and makes it essential to improve the coordination of their work. This increases the extent of the role played by the sections of VÉO as centers which unite entomologists working in different institutions and branches of the national economy, and which serve to exchange work experience and attract young recruits.

As previously, the most active sections during the past year were the Moscow, Ukrainian, Siberian, Georgian, Uzbek, Latvian, Voronezh, and Ivanov sections. Work was performed in the recently created Turkmenian and Belorussian sections and in the newly organized Sakhalin section. Work was carried out on the organization of a Tadzhik and Far Eastern section; the Siberian section started affiliations in Tomsk, Krasnoyarsk, and Irkutsk. Aside from these, in several sections (the Kazakh, Kirgiz, and Moldavian) work proceeded in a very lethargic manner, while in the Rostov and Sochi sections it practically ceased altogether.

The Moscow section of the Society tied its work in with that of other scientific societies by means of holding joint meetings with the Zoological Section of the Moscow Society of Naturalists, the Moscow affiliation of the Geographical Society of the USSR, and the Section on the History of Biology of the Soviet National Union of Historians of Natural Science and Technology. One of the meetings was devoted to the problem of the Colorado beetle; as a result a letter was discussed and adopted to be sent to VASKhNIL with the request that the work on the study of this dangerous pest and its control be intensified.

Great work directed primarily to the solution of practical problems was carried out by the Uzbek, Georgian, and Ukrainian sections. Considerable success was achieved by many sections (especially the Ivanov, Moscow, Uzbek, and Latvian) in liquidating the debt of membership dues and registering Society members for the subsequent formulation of a list of members for a jubilee collection on the 100th anniversary of the All-Union Entomological Society.

Unfortunately, the tardy submission of their reports by several sections, in particular such major actively working ones like the Ukrainian, has not enabled us to reflect their activities to the necessary extent in the present account.

In its work for 1959 the All-Union Entomological Society is called upon to accomplish the fulfillment of the notable tasks set by the historic 21st Congress of the CPSU to sharply increase the agricultural productivity of our country, to improve the health protection of the Soviet people, and to further develop the theories of biology. In order to do this, the Society must develop its activities in the following ways:

1) By further strengthening of bonds between entomological science and practice, in particular with agriculture, forestry, and health, with a raising of the theoretical level of research.

2) By improvement of the work of the Council of the Society and especially its relation with the sections, and also by improvement in the presentation in the Council of the Society of direct information on the work of the sections and a broadening of direct contacts between the sections.

3) By further recruitment into the ranks of the Society of practical workers in agriculture, health, and other branches of the national economy, and the participation of youth.

4) Preparation for holding the 4th (jubilee) session of the All-Union Entomological Society in January and February, 1960.

5) By the continuation of efforts to expand publication activity through:

a) increasing the pagination of the journal "Entomological Review" from 60 to 90 quires (6 issues) per year;

b) the transformation of the "Trudy VÊO" from several irregular issues to a regularly appearing publication (two volumes a year with an average pagination of 40-50 pages);

c) the regular issuance of publications in the popular series.

6) By further improvement in acquisitions for the Library of VÊO, especially through the expansion of direct exchanges of Society publications with foreign scientific institutions.

Presidium of VÊO

BOOK REVIEW

I. A. Rubtsov. Black Flies. Fauna of the USSR. Diptera, vol. VI, issue 6, 2nd ed., 1956, 860 p., 424 fig. Price: 51 rub. 20 k.

Fifteen years after the appearance of the first edition of I. A. Rubtsov's Monograph "Black flies" a second, completely revised edition of this book, almost twice as large as the first one, has come out. It embraces practically all the black fly fauna presently known for the Palaearctic Region, not including certain marginal territories (North Africa, Japan).

The appearance after such a comparatively short time of a new edition of this volume of the "Fauna SSSR" is the result of the considerable increase of knowledge in recent years in the field of the systematics of black flies. It is I. A. Rubtsov himself who has made a large contribution in this area, having described, up to the time of appearance of the book here reviewed, 247 species and subspecies, 2 new genera, and one new subfamily out of a total of 344 taxa included in the book. Of these, the book here being reviewed contains the descriptions of 96 new species and 29 new varieties.

In comparison with the first edition the number of pages allotted to the general portion of the monograph has been reduced. Consequently, in the new edition the author has allotted more than twice the number of pages to the systematic section, taking into account a trend in the entire series. However, having reduced the length of the general portion it definitely does not follow that the author has devoted less attention to the revision and supplementation of the general portion in relation to the systematic one. Numerous new data and original observations by the author on many problems, more compactly presented, and many very explicit illustrations make this section no less valuable than the systematic one.

The section on anatomy and morphology contains not only detailed descriptions of the external and internal structures of the imagines of both sexes and all developmental stages, greatly exceeding the requirements of systematics, but also contains, as a unit within it, an exact characterization of the functions of all the described structures on the basis of the latest literature data and numerous original observations by the author. The chapter on the biology (more correctly, the bionomics) of the imago and the aquatic stages is handled accurately and in detail, with the author considering the consequences of separate effects (for instance, of phenology, number of generations, developmental cycle, migration, etc.) on systematics, but by no means limiting himself to the requirements of the latter. The most important natural enemies of black flies are surveyed in detail in tabular form. In this section the author devotes attention to the important gaps existing in our knowledge of this field. In the chapter on the medical and veterinary importance of black flies the author emphasizes the necessity for allocating greater attention to black flies not only as direct parasites, but also as specific or nonspecific vectors of various dangerous diseases of both man and domestic animals.

Subsequent chapters deal with questions of the composition and geographical distribution of the black fly fauna in the USSR, various systematic problems—the variability of species, their phylogenetic relationships, a natural classification of the families, etc. A special section is devoted to problems of method: collection, preservation, and determination of black flies. In this section the author acquaints the reader with his wealth of practical experience and the results of a long and manifold personal systematic study of the black flies. The last chapter of the general portion—on the means of protection from black flies and their control—summarizes the rich Soviet and foreign experience in this field.

The most important contribution, however, is the almost completely revised systematic portion which consists of about 700 pages of text and about 400 composite illustrations of necessarily schematized but very explicit diagrams of the developmental stages of almost all the included species and lower taxonomic units available to

the author. In comparison with the first edition, the author has introduced several fundamental changes in general concept with regard to the classification of the Simuliidae. Some of the previous subgenera, such as Wilhelmia, Boophthora, Odagmia, and others, are elevated to the rank of genera and others are eliminated. As a result the subgeneric category is not used by the author and the closely related species are grouped within the various genera as groups which correspond approximately to the large, or Linnean, species used by other authors in other groups, and which are named after the commonest of the hitherto known species, such as: the group E. latipes (39 forms, including E. costatum), the E. angustitarse group (10 species), the E. aureum group (13 species), etc. It is interesting that the author uses the works of Enderlein to a greater extent than has been done hitherto by the greater majority of investigators (Smart, 1955; Grenier, 1953). A detailed systematic study, on the basis of all the available data, used by the author in this and previous works shows that the majority of the species, although insufficiently described by Enderlain, corresponds to reality and that the number of species included by the latter better reflects the actual situation than the too timorous determinations of the Western authors.

It is understood that this book, which presents so much new material on the hitherto poorly known group of black flies, cannot be considered as definitive in all respects; future investigations will naturally lead to the need for a more accurate delimitation of some genera, either broadening or narrowing them, or even to the redistribution of several species, while a revision of the material presented by previous authors will probably lead to some changes in the conception of these species.

However, this in no way affects the fact that the new edition of I. A. Rubtsov's book is an indispensable text for anyone who is seriously interested in the simuliid group and that this book, with its new data, broad approach to the subject, and all its concepts, marks the beginning of a new level in the investigation of this diversely important group.

Vladimir Novak (Prague)

A.I.B.S. Russian Monograph Translations

The AIBS is in the process of expanding its Russian Translations Program extensively. Funds to subsidize translation and publication of important Russian literature in biology have been obtained from the National Science Foundation, as part of a larger program to encourage the exchange of scientific information between the two countries. The following monographs have been published:

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The following Russian Monographs are being translated. Publication date to be announced.

Problems in the Classification of Antagonists of Actinomycetes. *By G. F. Gause.*
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